ELECTRICAL ENGINEERING

JULY 1960
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THE COVER: An Atlas ICBM takes off from the Air Force Missile Test Center, Cape Canaveral, Fla. Particles in air on left side of missile are bits of ice and frost formed as a result of liquid oxygen (—297 F) in the missile tank being shaken off by the vibration of engines developing 360,000 pounds of thrust. Produced by Convair (Astronautics) Division of General Dynamics Corp., the Atlas serves as a major deterrent weapon in the arsenal of the Air Force Strategic Air Command. Story on p. 619.

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SELECTIVITY CURVES *show tripping times for all breakers in your G-E Load Center—your assurance of SELECTIVE COORDINATION under all conditions. Ask for them.*

Selectively Coordinated Load Centers Deliver . . .

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. . . Yet you pay no price premium if you buy from General Electric

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SELECTIVELY COORDINATED Load-Center Unit Substations are your best assurance of power continuity. Power circuit breakers are factory-preset by General Electric so that—during short-circuit conditions—only the circuit breaker on the faulted feeder opens. Power continues to flow through unfaulted circuits to the rest of the loads. This "selectivity" between main and feeder breakers is accomplished by coordinating the tripping time of the main and feeder breakers.

During any magnitude of feeder short circuit, the main breaker "waits" until the feeder breaker opens.

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You now can have this superior coordination at no extra cost. Advanced engineering techniques by General Electric have eliminated the price premium normally charged for this inherently higher cost, more highly-engineered unit substation. In addition, you can save by using manually operated, stored-energy breakers in place of electrical units which were formerly required.

DESIGN WITH ARNOLD 6T CORES... SAME-DAY SHIPMENT OF STANDARD DELTAMAX CORE SIZES

Arnold 6T tape cores (aluminum-cased and hermetically-sealed) offer you three very important design advantages. *One:* Maximum compactness, comparable to or exceeding that previously offered only by plastic-cased cores. *Two:* Maximum built-in protection against environmental hazards. *Three:* Require no supplementary insulation prior to winding and can be vacuum impregnated after winding.

Now we've added a fourth vital advantage: Maximum availability. An initial stock of approximately 20,000 Deltamax 1, 2 and 4-mil tape cores in the proposed EIA standard sizes (See AIEE Publication No. 430) is ready on warehouse shelves for your convenience. From this revolving stock, you can get immediate shipment (*the same day order is received*) on cores in quantities from prototype lots to regular production requirements.

Use Arnold 6T cores in your designs for improved performance and reduced cost. They're guaranteed against 1000-volt breakdown . . . guaranteed to meet military test specifications for resistance to vibration and shock . . . guaranteed also to meet military specifications for operating temperatures. The 6T hermetic casing method is extra rigid to protect against strains.

Let us supply *your* requirements. Full data (Bulletin TC-101A and Supplements) on request. • Write *The Arnold Engineering Company, Main Office and Plant, Marengo, Ill.*

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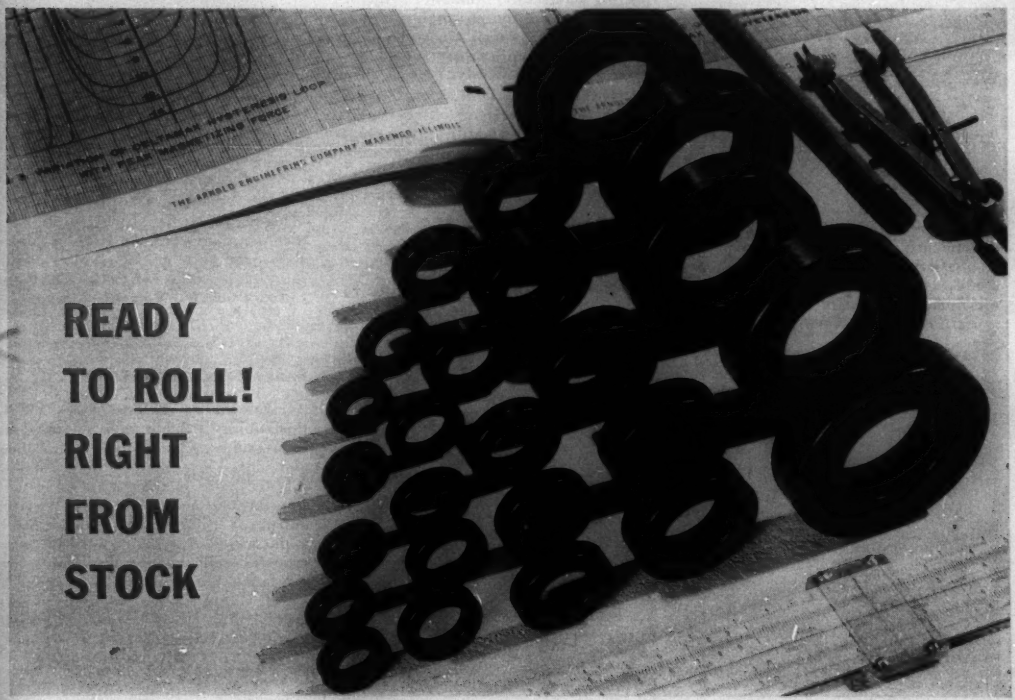
1539



New and Improved Products . . .

Nontracking Plastic . . .

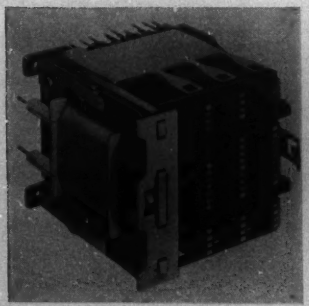
A new Fiberglas reinforced alumina-polyester molding compound called Resistrac combines the toughness and moldability of high impact plastics with the carbon tracking and flame resistant qualities essential to most indoor applications currently using ceramic materials. Under suggested ASTM (American Society for Testing Materials) tracking resistance tests, samples exhibited no carbon formation after 400 hours of test. *The Glastic Corp., 4321 Glenridge Rd., Cleveland 21, Ohio.*

Connector . . .

This giant 10,000-ampere braided connector, the largest yet made, will connect the neutrals of an Allis-Chalmers steam turbine–generator capable of producing 282,000 kva at 20,000 volts. The generator studs are on 42-inch nominal centers with provision for $\pm 1/2$-inch movement. Eight feet long, the connector weighs approximately 700 pounds. *Penn Union Electric Corp., Erie, Pa.*

Wire Spring Relay . . .

Series *WQA* wire-spring relay was designed to transfer up to 51 circuits at high speed for 100 million or more operations without the need for readjustment. A unique armature actuating card operates all moving wire-spring contacts simultaneously and independently. The movable springs are aligned and anchored in a molded assembly, while a plastic comb aligns the relay's stationary springs. *Automatic Electric Co., Northlake, Ill.*



Ultrasonic Cleaner . . .

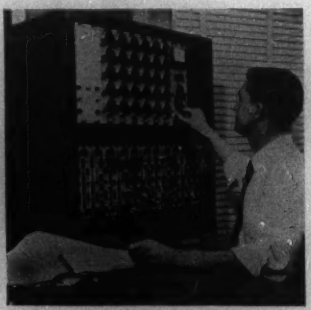
Increase the efficiency of the transducer, and the over-all effectiveness of the ultrasonic cleaner will be increased. A new zirconate titanate transducer is expected to replace the barium titanite ones now in use since 1953. Anticipated advantages are: high efficiency output (90% compared with 70% for the barium titanate), a 200 F operating temperature limit (compared with 160 F for barium), flat tuning characteristics that will reduce the need for close frequency control of the generator, and a capacity to accept higher electric input power for conversion into mechanical energy. *Branson Ultrasonic Corp., 40 Brown House Rd., Stamford, Conn.*

Airborne Frequency Standard . . .

One-tenth the size and weight of conventional ground frequency standards, this latest development for the Wright Air Development Division weighs only 65 pounds and has a volume of less than $1\frac{1}{2}$ cubic feet. For use in navigation, guidance control, and communication channeling in aircraft or missile systems, the instrument is capable of maintaining a field frequency stability for life of better than one part in one billion, or one second in 300 years. Greater stability is inherently possible when the instrument is operated under laboratory conditions. *National Company, Inc., Malden, Mass.*

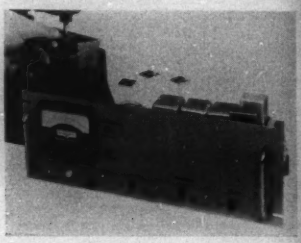
Differential Analyzer . . .

Developed by four University of Michigan professors in their spare time, the *AD-1* is a low-cost desk-top electronic analog computer that is capable of being expanded to keep pace with the needs of small, growing firms. Because it is built on a modular principal, more complex components may be added when needed. Thus, a firm can add such components as a preprogrammed, removable patchboard system, up to 64 amplifiers, electronic multipliers, and diode-function generators. *Bowmar Instrument Corp., 8000 Bluffton Rd., Fort Wayne, Ind.*



Sensitive Relay . . .

Input signals of 2 microwatts into this relay are sufficient to control 600 watts of output power, a ratio of 1 to 300 million. Prime application of the



device is in the field of process control. Driven from low-level electric signals or the output of differential transformers, strain gauges, gas analyzers, bridges, or temperature-sensitive elements of photocells, the Regohm Meter Relay can sort, grade, classify, alarm, indicate, or control. *Electric Regulator Corp., Pearl St., Norwalk, Conn.*

Epoxy-Glass Rolled Tubing . . .

Known as Dilecto *GB-125EFR*, this tubing is made from epoxy resin impregnated glass cloth that is rolled and cured on mandrels. The new tubing grade is designed for use in transformers and other heavy electric apparatus including electronic military applications. Excellent physical properties as well as flame retardance, arc resistance, and high flexural strength at 150 C, are some of its more important features. *Continental-Diamond Fibre Corp., Newark, Del.*

(Continued on page 10A)

the main characteristic of every Sorgel dry-type transformer is...

QUIET QUALITY

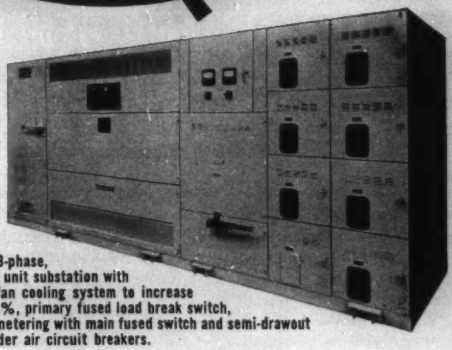
Still setting the industry's pace for lowest sound levels . . . Sorgel's New 1960 Line features additional reductions in size and weight!

A great many independent authorities agree that Sorgel Sound Rated Dry-Type Transformers have historically been the industry's Quiet Quality line. Biggest human reason why: Men with a desire for excellence make Quiet Quality a crusade at Sorgel. Significant results: (1) The industry's lowest sound level. (2) Unexcelled overload capacity. (3) Unequalled operating efficiency. (4) Long range economy. Proof: Certified tests and case history engineering data, furnished upon request, substantiate Sorgel's Quiet Quality performance. Customer benefits: Complete satisfaction and appreciation.

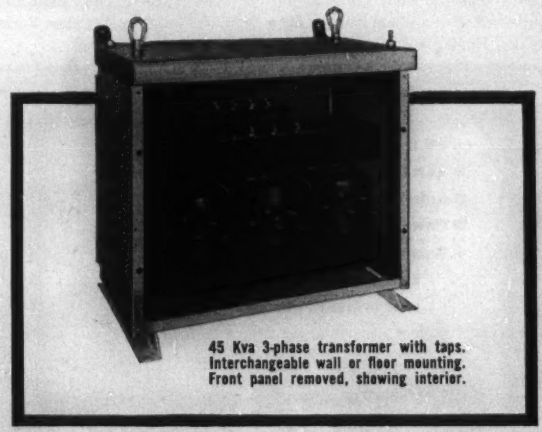
Sorgel also offers these proven advantages:

- **Lower Copper Loss** — *Coils are liberally designed for the most effective use of the latest developments in insulating materials, have large air ducts for low hot spot temperature and are vacuum-impregnated to provide a co-ordinated insulation system.*
- **Lower Core Loss** — *Cores are designed with the industry's lowest magnetic flux densities, resulting in low core loss and the lowest sound level. Entire unit is secured within a substantial frame. Large units are mounted on vibration dampers to minimize vibration transmission to adjacent areas.*
- **Quicker, Easier Installation**—*The enclosure is self-supporting and entrance can be made on sides, top, bottom, or back. Connecting is made easier by means of solderless connectors on terminal blocks in roomy connection compartments. Units up to 75 Kva single phase and 45 Kva 3 phase are furnished for interchangeable wall or floor mounting.*

The same quiet SORGEL transformers are also incorporated in substations. Procurable with any type or make of switchgear, or from any electrical manufacturer. Contact Sorgel today for the Double "Q" in dry-type transformers . . . Quiet Quality.



1500 Kva, 3-phase, 12,000 volt unit substation with automatic fan cooling system to increase capacity 33%, primary fused load break switch, secondary metering with main fused switch and semi-drawout fusible feeder air circuit breakers.



45 Kva 3-phase transformer with taps. Interchangeable wall or floor mounting. Front panel removed, showing interior.

Complete Line for Every Purpose up to 10,000 Kva, up to 15,000 Volts, Including Special Transformers and Saturable Reactors

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846 West National Ave., Milwaukee 4, Wisconsin

Sales engineers in principal cities. *Consult the classified section of your telephone directory or communicate with our factory.*

TO 600,000 VDC

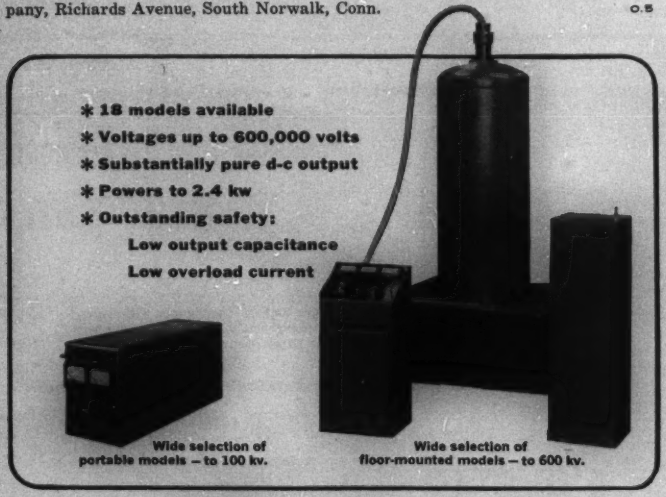
...something new in high voltage!

ELECTROSTATIC GENERATORS FOR INDUSTRY

SAMES Electrostatic Generators, producing substantial amounts of output power at voltages up to 600 kv, are the first such generators ever designed for day-to-day industrial use. They're marketed in the U.S. exclusively by Sorensen.

Output voltage is very nearly pure d-c, marked by the almost complete absence of ripple or other a-c components. Voltage regulation ranges from 4% to 0.33% for medium stability models and from 0.1% to 0.001% for high stability models.

You'll find these advanced high-voltage d-c sources described in the new 6-page SAMES brochure. A new 32-page Sorensen catalog is also available which lists more than 400 models of high-precision power supply equipment and gives valuable selection and application data. Write for your copies today. Sorensen & Company, Richards Avenue, South Norwalk, Conn. O.5


* 18 models available
* Voltages up to 600,000 volts
* Substantially pure d-c output
* Powers to 2.4 kw
* Outstanding safety:
Low output capacitance
Low overload current
Wide selection of portable models — to 100 kv.
Wide selection of floor-mounted models — to 600 kv.

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CONTROLLED POWER PRODUCTS

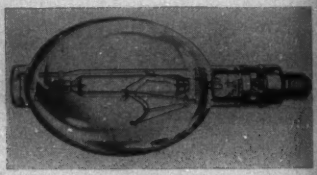
...THE WIDEST LINE MEANS THE WISEST CHOICE

New & Improved Products

(*Continued from page 8A*)

Industrial Electric Bulb . . .

Life-rated at 10,000 to 12,000 hours, this new Fluomeric bulb brings the intensity and color of natural sunlight into commercial establishments or industrial plants by combining the



features of incandescent, fluorescent, and mercury lighting in one envelope. The bulb will deliver 60,000 lumens at 1,750 watts, twice the light at work level, without increased wattage. It requires neither ballast, new wiring, nor special socket. *Duro-Test Corp., North Bergen, N. J.*

Diesel Engine Control . . .

An electric governor-wattmeter for precise control of diesel engine driven generating sets maintains speed and output frequency of generator sets within ¼% of the desired value. Basically a droop-type governor with a speed droop of 1.5% from zero to rated load, the unit employs a magnetic-amplifier wattmeter circuit to sense the power load and reset the speed. The same load signal is used to operate an indicating wattmeter, and, in the form of load anticipation, to reduce transient frequency errors. *Consolidated Controls Corp., Bethel, Conn.*

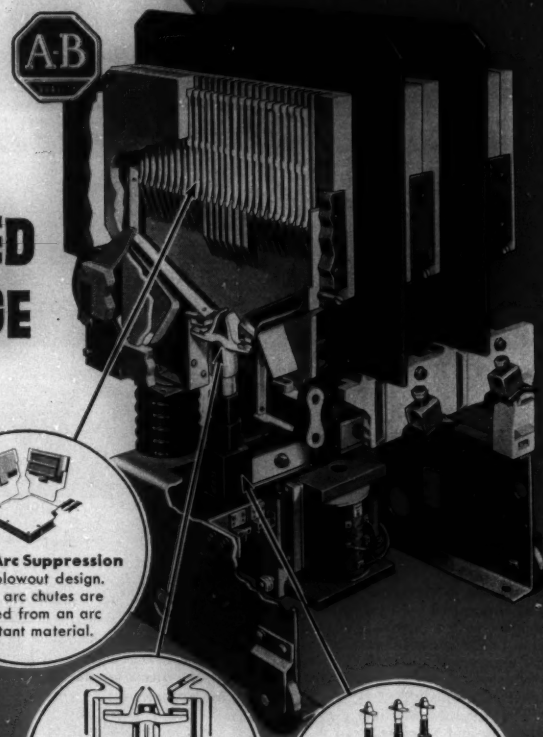
Tube-Cooled Motors . . .

These tube-cooled air-to-air heat exchanger motors are designed to operate in unfavorable environments providing protection against excessive moisture, oil vapor, chemicals, alkalies, coolant and air-borne dust, sand, dirt, and metallic particles. Ranging in sizes up to 2,000 hp, the motor has other features including corrosion resistant construction, capsule-type split sleeve bearings, and pressure lubricating systems with oil level indicators. *The Louis Allis Co., Milwaukee 1, Wis.*

(*Continued on page 16A*)

Here's the inside story of industry's

MOST RUGGED HIGH VOLTAGE SWITCH



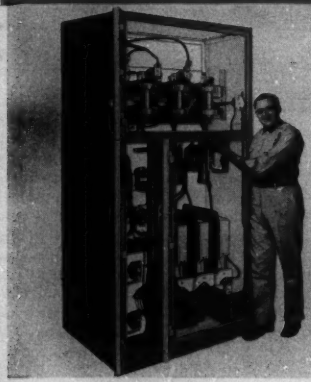
THIS SOLENOID AIR BREAK CONTACTOR IS THE HEART OF THE A-B STARTER LINE

A tremendous operating life has been built into these new A-B high voltage, air break starters by using the same simple solenoid design—with only ONE moving part—that has proved good for millions of trouble free operations in Allen-Bradley low voltage starters. A-B high voltage starters are made for all types of service and for all types of motors up to 1500 hp, 2300 v; 2500 hp, 4600 v. Send for Publication 6080, today.

Faster Arc Suppression
New blowout design. Novel arc chutes are molded from an arc resistant material.

Double Break Contacts
Silver alloy contacts never need maintenance. Vertical motion assures uniform contact pressures.

Only One Moving Part
Simple solenoid design eliminates trouble-causing pins, pivots, and flexible jumpers.



A-B High Voltage Starter with Air Break Contactor

Bulletin 1159 high voltage air break, across-the-line induction motor starter in NEMA Type 1 enclosure. All Allen-Bradley high voltage starters are equipped with current limiting fuses with interrupting capacities of 150,000 kva at 2300 v; 250,000 kva at 4600 v.

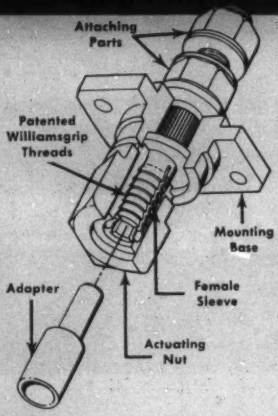
ALLEN-BRADLEY

Member of NEMA

Quality Motor Control

Allen-Bradley Co., 1301 S. First St., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

WILLIAMSGRIP
single circuit
quick
disconnect



Williamsgrip electrical connectors provide quick connect and disconnect with a flick of the wrist... plus full positive connection insuring maximum conductivity without the use of springs, slip joints or friction methods.

The patented Williamsgrip construction and special thread design prevents slippage and corrosion, resulting in cooler operation, greater reliability and longer life.

The self-wiping action of the connector eliminates arcing and excessive heating, and allows the connector to operate from 5° to 25°F cooler than the cable, even under conditions of 100 percent overload. Both connectors and adapters are constructed to withstand severe environmental conditions, and have successfully withstood temperatures over 2000°F.

These high current, single circuit connectors covering a wide range of wire and cable sizes have proved their reliability over more than a decade of versatile, rugged service for a wide variety of requirements in the military, industrial and commercial fields.

Write today for AiResearch Product Catalog on "Electrical Connectors."

THE GARRETT CORPORATION
AiResearch Manufacturing Division
Los Angeles 45, California

New & Improved Products

(*Continued from page 10A*)

Ruling Pen Gauge . . .

Here is a pocket calibrator that will take the guesswork out of ruling pen line widths. A jackknife arrangement of 25 steel feelers ranging in thickness from .00015 to .0025 inch may be selected for insertion between the pen's blades. By using these standards, an exact match can be made between ruling pen and compass pen, or new work and old. *Laramie Chemical Corp., P. O. Box 266, Ridgeway Sta., Stamford, Conn.*

Corona Tester . . .

Traces of corona, whether caused by voids within an insulating structure, insufficient clearance, or other material or assembly defects, are detected and measured with this instrument. The system consists of a specially designed corona-free high potential tester to provide high test voltage, a corona-free capacitor divider, and a filter network to extract the corona signal. The corona detecter is a high-gain wide-band amplifier that feeds a high-sensitivity oscilloscope. *Associated Research, Inc., 3777 W. Belmont Ave., Chicago 18, Ill.*

Static Eliminator . . .

With this Aerostat blower-ionizer, static can be neutralized at distances up to 4 feet on materials passing through the air stream. One typical application is in the manufacture of large, intricately shaped plastic parts, where the molded pieces require that both outside and inside be neutralized simultaneously. Another is in the graphic arts, where Aerostats on each side of the delivery pile assure perfect jogging by blowing neutralizing air over sheets that often become charged by air friction "on the fly." Still other uses are in textiles where static may be discharged in the weaving area between the warp and filling thread. Another is in the manufacture of photosensitive films and papers for prevention of static fogging sparks. *The Simco Company, 920 Walnut St., Lansdale, Pa.*

Cooling Coil System . . .

Type *7585* ignitron features a unique spiral cooling coil that is so distributed as to concentrate cooling action around the discharge chamber, thereby promoting condensation at the bottom of the tube and reducing the chance of arc-back. Designed for single-phase welding controls and similar applications, the component is compatible and interchangeable with all existing C-size tubes with electrical characteristics identical to the standard type *5552A. Amperex Electronic Corp., 230 Duffy Ave., Hicksville, N. Y.*

Hand Calculator . . .

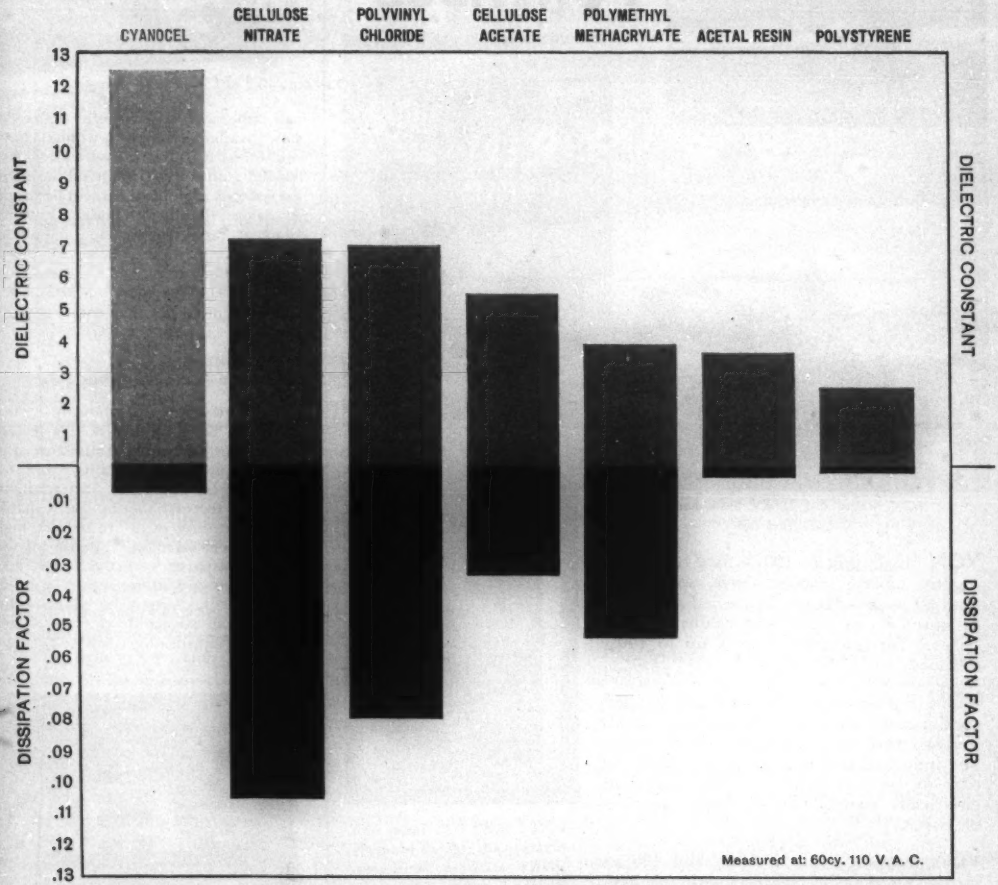
By rotating a wheel on the Dialor, the relations between displacement, velocity, and acceleration may be precisely determined according to the theory of sinusoidal motion. Given the frequency and one function, the user can obtain the magnitudes of the other two. Vibration, which is random in nature and of uniform spectral density, also behaves according to well-defined laws. Therefore, solutions to the equation relating acceleration density, frequency bandwidth, and rms acceleration, may also be calculated with this device. *Ling-Altec Electronics, Inc., 1515 S. Manchester, Anaheim, Calif.*

(*Continued on page 20A*)

NEW CYANOCEL* (CHEMICALLY MODIFIED CELLULOSE)

HIGHEST DIELECTRIC CONSTANT!

LOW DISSIPATION FACTOR!



Cyanocel is new and different! It can be cast into film—molded at very high temperatures. It's already being used in electroluminescent lighting—and it's ready for your investigations! Write on your letterhead for technical literature and experimental samples. *Trademark

AMERICAN CYANAMID COMPANY

PETROCHEMICALS DEPARTMENT • 30 ROCKEFELLER PLAZA • NEW YORK 20, NEW YORK

CYANAMID

High Voltage
High Power
and still
PORTABLE

VON Model C-1 100KV 5MA Portable
D.C. Test Set

VON basic unit of 100KV 5MA continuous output (.5KW), shown above, weighs less than 80 pounds. It can be carried as luggage or stored in an instrument cabinet. It can be used for intermittent work up to 100% overload.

VON test sets were designed as unregulated, continuously variable, low ripple, fully instrumented D.C. equipment for utility and industrial testing applications. They are easy to operate. They are physically and electrically rugged. VON testers are free of X-RAYS.

VON topping units of 50KV and 100 KV increments may be obtained with the basic unit or added later to extend the range to any desired voltage.

VON 1KW and 2KW testers also available.

VON (.5KW) D.C. Tester with topping units stacked to supply 250 KV at 2 MA continuous. Weighs less than 150 pounds.

Write For Complete Information

P.O. BOX 3566

BIRMINGHAM, ALABAMA

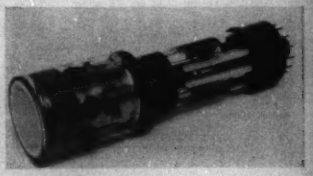
THE VON CORPORATION

New & Improved Products

(Continued from page 16A)

Small Storage Tube . . .

Only 2¾ inches in diameter and 9$^{11}/_{16}$ inches long, the new Storatron is said to be the smallest direct-view storage tube with electrostatic deflection now available. A conventional base, one of its features, includes two glass-rodded guns for electrical and mechanical stability. Applications will be found in narrow bandwidth video transmissions at radio frequencies, telephone transmission lines, equipment monitoring, and freezing of transients. *Allen B. Du Mont Laboratories, Inc., 750 Bloomfield Ave., Clifton, N.J.*



Quartz-to-Metal Sealing . . .

A new method of placing a thin metalized layer on quartz now makes it possible for the first time to produce in quantity production quartz-to-metal seals that are vacuum-tight, stable to thermal shocks, and capable of withstanding exposure to very high electric field strengths. Because of the high transparency to infrared and ultra-violet radiation, useful applications will be found in photo cells, lamps, and waveguide devices. Other promising applications will be for television camera tube envelopes, and atomic radiation devices, where electron bombardment and exposure to X rays will cause little appreciable discoloration. *Eitel-McCullough, Inc., San Carlos, Calif.*

(Continued on page 29A)

AIEE in Electrical Engineering Education—Yesterday or Tomorrow?

T. M. LINVILLE
FELLOW AIEE

A discussion of some of the major problems and opportunities in engineering education facing the Institute. A new operating group or National Division, allied with the Education Committee, is urged to draw into activity the many willing members for whom there is no place within the present scope of the Education Committee.

THE TASK of engineering educators in designing curricula would be a hopeless one if it were not for the fact that graduates can be equipped to adapt themselves quickly to specific practical situations. When you identify the specialized fields within electrical engineering according to the technical committees of AIEE and the Institute of Radio Engineers (IRE), (see Table I) it appears that the colleges could not possibly educate students for all specific fields. Consequently, they are turning to curricula containing the fundamentals common to all fields of electrical engineering and, for that matter, substantially all engineering. This leaves it to industry to ease the graduate into specialized work and to educate him in the practices peculiar to such specialties. Chances are that his fundamental knowledge will stand him and his company in good stead when his services are needed in new fields for new business opportunities. Engineers have had to venture into new fields in recent years, beyond the practical aspects of their academic learning, with the advent of systems engineering, and of electronic and atomic technologies and applications. They will have to do so in the future, next time possibly in the power and consumer products industries, when new business opportunities are born from the basic attention being given to energy conversion by fusion reactors, fuel cells, thermoelectric devices, and magnetohydrodynamics.

Sooner or later there will be new glamour and fascination for students with respect to the power industry. The first question of this article is what can be done to infect the students with the new glamour and change in the power industry field? Those graduating this year will be among the ones bringing the changes about even though substantial changes may be 40 years away. The second question is how far should we go in educating engineers in fundamentals to the exclusion of practices? Fortunately, the latter question has been answered substantially by the ASEE (American Society for Engineering Education) studies and by the development of ECPD (Engineers' Council for Professional Development) accreditation criteria. The "core" studies of engineering education (in the engineering sciences) provide the root of the answer in the area of undergraduate college curricula.

These are only two of the problems on which the AIEE can help through the activities sponsored by its Education Committee. These activities serve to bring people from education together with people in industry to work on problems where mutual interest and understanding is needed. Included among the activities is the task of keeping the membership informed of the problems and how the college and industry are meeting them.

The commencement of AIEE's fourth quarter-century is an appropriate time to review and appraise what the Committee is doing with engineering sciences and technology exploding all around us. Are we making the transitions from what we did yesterday to what we need to do for tomorrow to meet the problems of explosive change?

Possibly it will be sufficient to illustrate the activity of the Committee by citing three additional problems which should be of interest to all AIEE members.

STUDENT MEMBERSHIPS

ON THE COLLEGE CAMPUSES, students and faculty members are expressing desire for a single branch of AIEE and IRE with common membership, meetings, and publications. This problem is the responsibility of the AIEE Student Branch Committee, but it has been brought to the attention of the Education Committee also. It springs from the position of the students and teachers who are pursuing a common curriculum in electrical engineering without specialization in, for example, communications or power. Their interests are not slanted toward one society or the other and, as far as the students are concerned, will not be until they have left college and taken their first job. Thus, they see no need for two societies on the campuses, both of which draw their attention, and dislike having to choose between membership in one society or the other. There is a joint branch on many campuses, but still the students must decide on one or the other, or both, for dues, membership, and publication purposes.

When this problem is considered, it leads to such questions as: why not joint sections, joint technical committees, etc.?—and then the problem is beyond the

A special article recommended for publication by the AIEE Education Committee.

T. M. Linville is with the General Electric Company, Schenectady, N. Y.

scope of the Education Committee. Former IRE President Fink has said a survey has shown that the two societies have in common, in addition to joint student branches: membership of 13%; committee membership of 25%; subcommittee membership of 31%; specific subject groups of 80 to 90%.

He has proposed a co-operative study for joint activities in limited areas. The Education Committee endorses this proposal, especially with respect to activities on the campuses, but thinks it should be a broad study covering all of the similarities and dissimilarities of the societies as indicated by the fields of interest of each. Meanwhile, the Education Committee has recommended unification on the campuses and consolidation of the AIEE Student Branch and Education Committees. This is quite a radical and far-reaching recommendation, changing things sharply from those of yesterday to meet the demands of today and tomorrow.

EXPANSION OF THE COMMITTEE

ANOTHER PROBLEM is that the Education Committee does not now include in its membership all of the AIEE members who would like to participate. Thus, the contribution of many members is lost. Moreover, the Institute's service to its members falls short of its opportunity. The facts are that there were 225 nominations for appointment to the Education Committee this year from which 33 members were appointed. Many more who did not volunteer are presumably equally interested, and only need to be called upon. Furthermore, interested members include at least 2,000 faculty members in accredited colleges who belong to AIEE, roughly an equal number in industry who have responsibility for recruiting on the campuses (it is not uncommon to find 500 companies recruiting on a single campus), and many more who have an active or passive interest.

Two alternate proposals have been made to meet this problem. One is to establish a large structure of subcommittees on various facets of education. The other is to establish a national Division of AIEE comprised exclusively of AIEE members on a voluntary basis, having its own officers, committees, meetings, and publication. This, then, would be the operating group of the Institute's organization for engineering education while the Education Committee would be a staff group.

With respect to this proposal, it is thought that such an operating organization would offer several advantages: it could determine and meet the needs of education more effectively than the present committee; it could provide for the affiliation on a voluntary basis of all interested members; and it could maximize the Institute's contribution to electrical engineering education.

Whatever are the consequences of this proposal which need to be determined, the Committee has before it for consideration a proposed petition to the Board of Directors for the establishment of a national Division for Engineering Education. This, again, is a radical proposal, making the Institute different tomorrow from what it was yesterday.

Table I. Standing Committees of AIEE and IRE.

American Institute of Electrical Engineers[4,5]

TOD (Technical Operations Department) Communication Division
- Communication Switching Systems
- Communication Theory
- Data Communication
- Radio Communications Systems
- Telegraph Systems
- TV & Aural Broadcasting Systems
- Wire Communication Systems

TOD General Applications Division
- Air Transportation
- Domestic and Commercial Applications
- Land Transportation
- Marine Transportation
- Production and Application of Light

TOD Industry Division
- Chemical Industry
- Electric Heating
- Electric Welding
- Feedback Control Systems
- General Industry Applications
- Industrial Control
- Industrial Power Rectifiers
- Industrial and Commercial Power Systems
- Metal Industry
- Mining Industry
- Petroleum Industry

TOD Instrumentation Division
- Aircraft and Flight Test Instrumentation
- Electronic and High Frequency Instruments
- Indicating and Integrating Instruments
- Nucleonic and Radiation Instrumentation
- Recording and Controlling Instrumentation
- Special Instruments and Auxiliary Apparatus
- Telemetering

TOD Power Division
- Insulated Conductors
- Power Generation
- Power Systems Communications
- Protective Devices
- Relays
- Rotating Machinery
- Substations
- Switchgear
- System Engineering
- Transformers
- Transmission and Distribution

TOD Science and Electronics Division
- Basic Sciences
- Computing Devices
- Electrical Insulation
- Electrical Techniques in Medicine and Biology
- Electronics
- Magnetic Amplifiers
- Nucleonics
- Semiconductor—Metallic Rectifiers
- Solid State Devices
- Standards
- Research
- Safety

Publications Department
- Educational Publications
- Periodicals and Transactions
- Special Publications

Professional Development and Recognition Department
- Education
- Registration of Engineers
- Professional Conduct
- Management
- Members-for-Life Fund
- Recognition Awards
- Edison Medal
- Lamme Medal
- Fortescue Fellowship
- Volta Scholarship Trustees
- Prize Awards

Admission & Advancement Dep't
- Board of Examiners
- Membership
- Transfers

Administration Department
- Public Relations
- Sections
- Student Branches

Board of Directors
- Executive
- Finance
- Constitution and Bylaws
- Planning and Coordination
- All Departments

Institute of Radio Engineers[6,7]

Standing (Technical) Committees
- Antennas and Waveguides
- Audio Techniques
- Circuits
- Electroacoustics
- Electron Tubes
- Electronic Computers
- Facsimile
- Feedback Control Systems
- Industrial Electronics
- Information Theory and Modulation Systems
- Measurements and Instrumentation
- Medical Electronics
- Mobile Communications Systems
- Navigation Aids
- Nuclear Techniques
- Piezoelectric and Ferro-electric Crystals
- Radio Frequency Interference
- Radio Transmitters
- Radio Receivers
- Recording and Reproducing
- Solid State Devices
- Television Systems
- Video Techniques
- Wave Propagation

Professional Groups
- Aeronautical and Navigational Electronics
- Antennas and Propagation
- Audio
- Automatic Control
- Broadcast and Television Receivers
- Broadcasting
- Circuit Theory
- Communications Systems
- Component Parts
- Education
- Electron Devices
- Electronic Computers
- Engineering Management
- Engineering Writing and Speech
- Human Factors in Electronics
- Industrial Electronics
- Information Theory
- Instrumentation
- Medical Electronics
- Microwave Theory and Techniques
- Military Electronics
- Nuclear Science
- Production Techniques
- Radio Frequency Interference
- Reliability and Quality Control
- Space Electronics & Telemetry
- Ultrasonic Engineering
- Vehicular Communications

Standing (Other) Committees
- Admissions
- Appointments
- Awards
- Awards Coordination
- Constitution and By-Laws
- Editorial Board
- Education
- Fellow
- Finance
- History
- Nominations
- Policy Advisory
- Professional Groups
- Tellers

PREPARATION OF POLICY

A THIRD EXAMPLE of the problems which the Committee is working on is the need to develop and publicize AIEE policy on education. The Committee believes the policy of the Institute should be formulated and made known to all members so that good influences can be exerted at countless points of official and individual contacts.

The Committee has gone about meeting this need in the following fashion. First, eight teams have been established with three committee members assigned to each team, to cover the following areas, respectively: (1) elementary schools, (2) secondary schools, (3) technical institutes, (4) undergraduate schools, (5) graduate schools, (6) industry programs, (7) AIEE programs, and (8) education of teachers.

The team members are preparing papers for presentation, discussion, publication, and to form a "Resource Report" for the Board of Directors. Details of subjects in these eight areas are to be presented in the summary portion of a "Resource Report." The Committee has given attention to information secured from the National Council for Better Schools, U. S. Chamber of Commerce (on industry-education co-operation), *Life* Magazine, *New York Times*, and the publications of AIEE, ECPD, and the ASEE. Some of this material[1, 2, 3] has been mailed to the members of the AIEE Professional Development and Recognition Department and the Board of Directors to acquaint them with the subject matter of the Committee's work.

In addition to the eight teams, a panel of eight members has been established to prepare a "Policy Guide Report," also for the Board of Directors, based on the "Resource Report."

It is intended that the panel will present this Report to the Committee as a whole at a special meeting and later at an open session at a national Institute meeting. Publication for broad availability is intended following Board of Directors' acceptance. The advent of AIEE progressive policy, calling the attention of all members to educational issues, will result in new equipment for the Institute of tomorrow.

CO-OPERATION WITH ECPD

THE RESULTS OF THIS WORK should assist ECPD through Institute representatives on that body. There are three representatives from AIEE to the ECPD Council, as there are from each of the other seven participating societies. IRE is not a member of the Council, so that AIEE carries the full responsibility for electrical engineering education here.

The range of ECPD's activities runs all the way from the public school level of education, through technical institutes, the colleges, and beyond. Therefore, the eight teams were established to serve because it was believed that this would cover the scope of the Institute's interest and responsibility, paralleling the range of ECPD's activities. One ECPD committee, for example, is concerned with advising high school students and their guidance counselors. In view of decreasing freshmen enrollment in the engineering colleges (20%) while secondary school graduating classes are increasing (12%), this activity has special importance. Other ECPD committees are concerned with training programs for engineers during their early years after taking their first jobs and with setting ethical standards.

CONCLUSION

THESE ARE BUT A FEW of the problems and opportunities confronting the Institute and receiving the attention of its Education Committee. We need to equip ourselves to handle any problem or any need with respect to education in electrical engineering. We need to bring educators and industry members together and have them exchange information, ideas, and opinions. We should make it easy for a much greater number of members to participate voluntarily. We need the proposed national Division to collect and make known the thoughts and recommendations of our members, and to report AIEE opinion and recommendations to ECPD and ASEE. We need an explosion here of the magnitude of the explosion in science and technology; we can, in short, meet the objectives of the Education Committee and: keep electrical engineering education fresh, vigorous, stimulated, and unbound; collect, distill, and make known the ideas and suggestions of members; develop and give recognition to leaders and leadership in education by AIEE; and make AIEE a most effective influence in education commensurate with its responsibility and opportunity.

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3. Crisis in Education. *Life*, series in five successive issues beginning March 24, 1958, New York, N. Y.
4. AIEE Organization Manual for 1958-59. Section B71, p. 150.
5. *Ibid.* Section B71.5, p. 151-52.
6. IRE Directory. Institute of Radio Engineers, New York, N. Y., section 80, p. 16.
7. *Proceedings*, Institute of Radio Engineers, vol. 47, no. 3, March 1959, p. 24A.

Bulb-Changing Price Lowered

Overhead light bulb replacement has been reduced from $8 per lamp to only $2 by use of a telescoping aluminum work platform called Tallescope at Northern High School, Pontiac, Mich. Folded down to pass through doorways, the lightweight tower is rolled into gymnasium and indoor swimming pool areas and quickly extended to reach fixtures. It can also be mounted on back of pickup truck for changing 25- and 30-foot-high floodlights in parking areas. In repainting and reroping flagpoles, tower saves about $25 per pole.

Tower is manufactured by Up-Right Scaffolds, Oshawa, Ont., Canada.

An Omnidirectional Circular Antenna Array

H. P. NEFF

J. D. TILLMAN
ASSOCIATE MEMBER AIEE

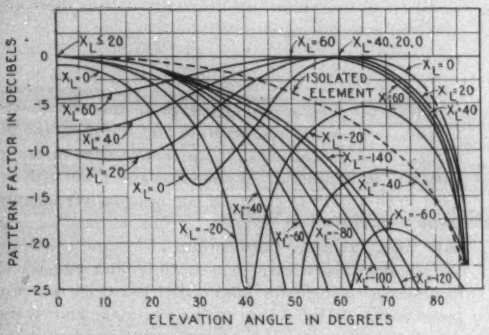

Fig. 1. Vertical patterns obtainable by varying parasite termination.

THERE IS a continuing practical need for antennas which radiate a pattern that is omnidirectional in azimuth, but which have a specified vertical pattern. Page[1] proposed that a circular array with a central element be used for this purpose, but his design requires that all of the elements of the array be driven. Here a method will be described of exciting such an array by means of only one driven element. The pattern factor of a circular array of axial dipoles is[2]

$$F_p = \left[mI_p J_0\left(\frac{2\pi\rho}{\lambda}\sin\theta\right) + 2\sum_{k=1}^{\infty} j^{km}\cos km\phi\, J_{km}\left(\frac{2\pi\rho}{\lambda}\sin\theta\right)\right] F_{ep} \qquad (1)$$

where m is the number of elements, I_p the current in each element in the ring, F_{ep} is the element factor of each element and ϕ and θ are the spherical co-ordinates of the remote point at which the pattern is evaluated, with $\theta = 0$ taken perpendicular to the plane of the circle, and $\phi = 0$ through element number m. The pattern of an element at the center of the ring is simply the element factor. If m is chosen large enough, the summation in equation 1 becomes negligible. The entire pattern of the array is then

$$F = I_c F_{ec} + m I_p F_{ep} J_0\left(\frac{2\pi\rho}{\lambda}\sin\theta\right) \qquad (2)$$

There is no dependence on the azimuth angle ϕ. There will be a null at a polar angle θ_n if the ratio of the current in the center element to the current in an element in the ring is

$$\frac{I_c}{I_p} = -\frac{mF_{ep}}{F_{ec}} J_0\left(\frac{2\pi\rho}{\lambda}\sin\theta_n\right) \qquad (3)$$

and inspection of equation 2 shows that this ratio must be real for the null to exist. If I_c/I_p is complex, there will be a quasinull at the angle θ_n given by

$$\Re\,\frac{I_c}{I_p} = -\frac{mF_{ep}}{F_{ec}} J_0\left(\frac{2\pi\rho}{\lambda}\sin\theta_n\right) \qquad (4)$$

and the depth of the quasinull will depend on the imaginary part of I_c/I_p.

The currents can be found from the circuit equations for the array.

$$\begin{aligned} V_c &= I_c Z_{cc} + I_1 Z_{1c} + \ldots + I_m Z_{mc} \\ -I_1 Z_L &= I_c Z_{1c} + I_1 Z_{11} + \ldots + I_m Z_{1m} \\ &\vdots \\ -I_m Z_L &= I_c Z_{mc} + I_1 Z_{1m} + \ldots I_m Z_{mm} \end{aligned} \qquad (5)$$

The coefficients here are the self and mutual impedances, and Z_L is the impedance in which the parasites are terminated. From symmetry, many of the mutual impedances are equal, and these equations reduce to

$$\begin{aligned} V_c &= I_c Z_{cc} + mI_p Z_{1c} \\ 0 &= I_c Z_{1c} + I_p({}_0Z + Z_L) \end{aligned} \qquad (6)$$

where ${}_0Z = Z_{11} + Z_{12} + \ldots + Z_{1m}$, and is called the zero-sequence impedance of the ring.[3]

$$\frac{I_c}{I_p} = -\frac{{}_0Z + Z_L}{Z_{1c}} \qquad (7)$$

which is the current ratio needed in equation 3.

A fortunate numerical result occurs when the ring-radius ρ is about 0.4 λ. At this radius ${}_0Z$ shows a type of resonance, and is a fairly small real number (about 8 to 10 ohms). If the termination Z_L is a pure reactance, the numerator is nearly a pure imaginary. At this spacing Z_{1c} is also nearly a pure reactance, so the ratio I_c/I_p is nearly real. The null angle can then be controlled by varying Z_L.

Fig. 1 shows the results that can be obtained, where the dimensions are $h_p = h_c = 0.25\ \lambda$, $\rho = 0.383\ \lambda$ and the parasite termination is varied. It is seen that this method results in good control of the vertical pattern, and since only one element is driven, the excitation of the array is very simple.

Digest of paper 60-11, "An Omnidirectional Circular Antenna Array Excited Parasitically by a Central Driven Element," recommended by the AIEE Broadcasting Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960. Published in AIEE *Communication and Electronics*, May 1960, pp. 190-92.

H. P. Neff and J. D. Tillman are with The University of Tennessee, Knoxville, Tenn.

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Electric Space Propulsion

J. C. EVVARD

General characteristics of electric propulsion systems for space vehicles, the energy sources and conversion efficiencies available, projected powerplant weights, and some of the various schemes for generating the ion and plasma jets. Also included are results of experimental units and their feasible range of application.

THE chemical rocket is likely to be limited to specific impulses less than 500. The corresponding temperature of the gas is on the order of several thousands of degrees Kelvin (K). The electrical acceleration of a singly charged positive ion through a potential drop as low as 1 volt corresponds to 11,600 K of temperature,[1] and many thousands of volts of acceleration are feasible. Thus, electric propulsion offers the promise of specific impulses that are orders of magnitude greater than can be achieved with either chemical or nuclear heat transfer rocket systems.

The electric rocket is a low thrust device. Thrust-to-weight ratios of about 10^{-4} are perhaps obtainable. The electric rocket must thus be launched into orbit by some other propulsion system, probably a chemical rocket. Once in orbit, the continuous application of thrust will add considerable energy to the space vehicle. The spiral path of a ship with a thrust of 1 pound for each 10,000 pounds weight will cross the moon's orbit in 83 days. Escape from earth's gravitational energy occurs in 127 days.

Trips to the edge of the solar system and beyond would be faster with the low continuous-thrust systems than with chemical rockets. The fuel requirement can be much less for the high specific impulse electric rocket than for the chemical rocket.

The energy requirements principally set the limits on the desirable jet speed. The jet power is approximately proportional to the mass flow rate $\dot{m}$, and the square of the jet fluid speed v.

$$P = \frac{1}{2}\dot{m}v^2 \tag{1}$$

The thrust is directly proportional to the jet speed

$$T = \dot{m}v \tag{2}$$

Hence, the product of the mass flow rate per unit thrust $(\dot{m}/T)$ and the jet power requirement per unit thrust (P/T) is a constant (Fig. 1)

$$\left(\frac{\dot{m}}{T}\right) \times \left(\frac{P}{T}\right) = \frac{1}{2} \tag{3}$$

Thus, if only low grade energy sources are available, such as in the chemical rocket, large mass flow rates will be required. If high grade energy sources are available, such as nuclear fission or fusion, then low consumptions of propellant are feasible. The power consumption rate per unit thrust is directly proportional to the specific impulse

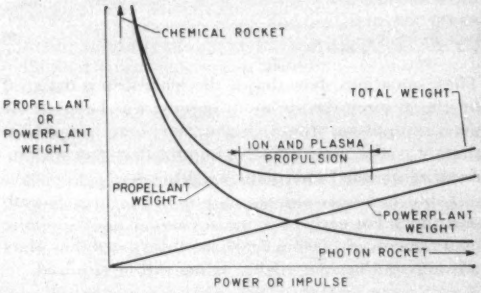

Fig. 1. Optimization of space propulsion systems.

$$\frac{P_e}{T} = \frac{1}{\eta}\left(\frac{P}{T}\right) = \frac{v}{2\eta} = \frac{I_g}{2\eta} \tag{4}$$

where η is the efficiency of converting electric power P_e to jet power.

MISSION ANALYSES

WEIGHT IS ALL IMPORTANT in the optimization of space flight systems. The primary reason for seeking higher specific impulses is to reduce the jet fluid consumption and, hence, the required fuel load for a given space journey. The jet consumption rate is $\dot{m} = T/I$. (The thrust is now written in weight units.) The fuel load for a propulsion time t is, therefore,

$$W_f = \frac{T}{I}t \tag{5}$$

On the other hand, the weight of the power generating equipment will increase with the required power output. The powerplant weight is

$$W_e = \frac{\alpha}{\eta}P = \frac{\alpha I T}{45.9\eta} \tag{6}$$

where α is in pounds per electric kilowatt. The total weight of power-plant energy source plus propellant is

$$\frac{W_f + W_e}{T} = \left(\frac{W}{T}\right) = \frac{t}{I} + \frac{\alpha I}{45.9\eta} \tag{7}$$

These weights are shown schematically in Fig. 1.

Abridged text of paper CP 59-1229 presented at the AIEE Fall General Meeting, Chicago, Ill., Oct. 11-16, 1959. Recommended for publication by the AIEE Aero-Space Transportation Committee.

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The minimum weight-to-thrust ratio is obtained when

$$I^2 = \frac{45.9\eta t}{\alpha} \tag{8}$$

so that

$$\left(\frac{W}{T}\right)_{opt} = 2\sqrt{\frac{\alpha}{45.9}\,\frac{t}{\eta}} \tag{9}$$

These equations show that if the space ship is designed for the mission, the optimum impulse will be lower for short propulsion times, higher for long propulsion times. Likewise, the optimum impulse decreases with increasing specific powerplant weight.

Table I shows optimum impulses for three propulsion times. For early missions in cislunar space, impulse requirements of 1,000 to 5,000 are anticipated. For Mars missions and beyond, higher values will be required.

Table I. Optimum Impulses*

Specific Weight, α/η	Propulsion Time		
	1 Month	2 Months	4 Months
1	11,000	15,550	22,000
3	6,350	9,000	12,700
10	3,470	4,900	6,940
30	2,010	2,840	4,020
100	1,100	1,550	2,200
300	635	900	1,270

*$I = 1{,}990\ \sqrt{t\eta/\alpha}$ where t is in days. The average month was taken as 30.5 days.

For a given mission, propulsion time is always a parameter in the payload capacity of the ship. By a combination of the propulsion time and the allowed trip time, the over-all weight-to-thrust ratio for the ship is determined by the celestial mechanics of the mission. When this information is combined with the fuel-plus-powerplant weight fraction (equation 9), the initial payload-plus-structural-weight fraction can be determined.

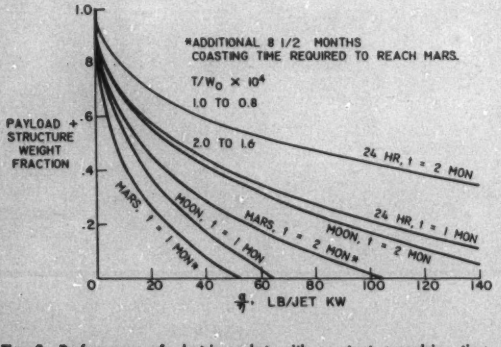


Fig. 2. Performance of electric rocket with constant propulsion time.

Fig. 2 shows the payload plus structural weight fraction that can be carried from a 300-mile orbit to a stationary orbit, to moon missions, and to Mars missions, all 1-way trips. This figure was computed using optimum impulses for each journey and ratio of α/η taking into account the loss in ship weight as the journey proceeds. Hence, the over-all thrust-to-weight ratio varies somewhat along each curve. For the Mars journey there is a coasting period following the thrusting portion of the flight. Clearly, larger payload-plus-structural-weight fractions can be carried for the longer propulsion times on each mission.

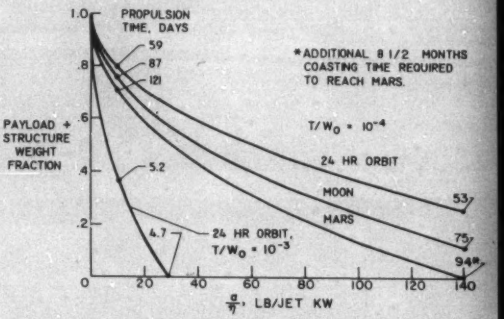


Fig. 3. Performance of electric rocket with constant thrust-to-initial-weight ratio T/W_o.

Fig. 3 shows the relation between payload-plus-structural-weight fraction and the specific powerplant weight for the stationary satellite, moon, and Mars missions. On these curves the thrust was held constant to yield an initial thrust-to-weight ratio of 10^{-4}. Thus, the weight of the space ship decreases with increasing time, and the thrust-to-weight ratio increases. Larger values of specific powerplant weight require lower optimum specific impulses with corresponding higher fuel consumption rates. Hence, on these curves lower propulsion times are required for larger values of specific powerplant weight than for small. The payload capability is correspondingly smaller.

In general, low specific powerplant weights are desired. If the payload does not require all of the payload fraction available, then the propulsion system can be increased in size or the ship weight decreased to yield still higher thrust-weight ratios and, hence, still shorter propulsion and trip times than these indicated in Fig. 3.

The large values of payload-plus-structural-weight fraction clearly show why electric propulsion is so interesting. The payload can be a large fraction of the ship's gross weight in orbit. This results from the high specific impulse achievable, and, hence, the fuel load can be orders of magnitude less for a given space journey than for the chemical rocket. The corresponding gross weight of the space ship in orbit, therefore, is much more reasonable. Electric propulsion is also of

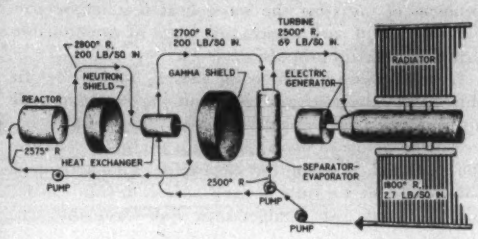


Fig. 4. Schematic arrangement of sodium cycle.

interest for other uses such as vehicle orientation and control.[2]

ENERGY SOURCES AND CONVERSION

From an inspection of Fig. 3 it would appear that the specific powerplant weight should be less than about 100 pounds per jet kilowatt. Even this rather high and somewhat arbitrary limiting value excludes many electric energy sources from further consideration for prime propulsion. The best chemical battery, for example, is several orders of magnitude too heavy for even 50-day propulsion times.

In fact, no chemical energy source can be considered. The inefficiencies associated with producing electricity for propulsion by chemical means will assure that such a system would be inferior to the chemical rocket.

The remaining feasible energy sources include solar radiation, radioisotope nuclear fission and nuclear fusion. Nuclear fusion is not useful at the present time. The radioisotope heat sources are impractical in large sizes because they are hard to handle, too heavy, and subject to the scarcity of radioactive material. Therefore, only solar and nuclear reactor energy sources are considered useful for electric propulsion.

The solar source has an intensity at the earth's distance from the sun of about 1.38 kw per square meter (0.128 kw per square foot). The conversion of this energy to electricity by means of solar batteries would not be much greater than about 10% efficient at the present time.[3,4] Hence, a kilowatt of electricity would require about 78 square feet of collection surface oriented normal to the sun's rays.

The specific weight of solar batteries is on the order of 100 pounds per kilowatt if they are in the sun full time. Considerable optimism is required to suggest that the specific weight could be lower than 20 pounds per kilowatt.

If the sun's rays were focused on a heat exchanger feeding a turboelectric system then perhaps efficiencies of 20% might be feasible. A 20-mw (megawatt) electric source utilizing a polyester balloon for focusing the sun's rays would require a diameter of 1,260 feet. If it were possible to retain such a balloon mirror of 0.001-inch plastic thickness inflated in the meteoroid environment of space, the over-all specific weight would be about 5½ pounds per kilowatt. However, there is sentiment among some experts that solar energy is impractical in space for electric power ranges above about 50 to 100 kw.

The nuclear reactor is the most probable energy source for large powerplants. A fairly long-life liquid-metal-cooled reactor might have a core density of 1 to 10 thermal mw per cubic foot. The heat from the reactor would be utilized to generate electricity either directly through semiconductors, or thermionic emitters or by means of a turboelectric system.

A schematic diagram of the turboelectric system[5] is shown in Fig. 4. The reactor feeds heat to a working fluid (sodium) passing through an evaporator and turbine. The turbine drives an electric generator and the necessary pumps to maintain the required flow rates. The sodium vapor is cooled and condensed in the radiator which rejects the waste heat to space by radiation.

Two sodium loops are used to simplify the problem of keeping radioactivity out of the radiator. The saturated liquid leaving the intermediate heat exchanger is sent to a separator evaporator where it is expanded to a reduced pressure. The vapor so generated is separated from the liquid by centrifugal force in the evaporator.

The specific weight of the various components making up the nuclear turboelectric system are shown in Fig. 5. In the 2-mw range, specific weights of about 10 pounds per electric kilowatt are foreseen. At 20 mw, perhaps a value as low as 6 pounds per kilowatt is feasible. In the 20-mw range, the radiator certainly adds the greatest weight fraction, amounting to 2.14 pounds per kilowatt.

The radiator also causes the greatest uncertainty in the weight analysis. The tube wall thicknesses were arbitrarily selected at 0.025 inch. According to the meteoroid penetration criteria of Whipple,[6] approximately 20 penetrations might be sustained during each day of operation under power. However, extrapolation of existing experimental data[7,8] on cratering effects of

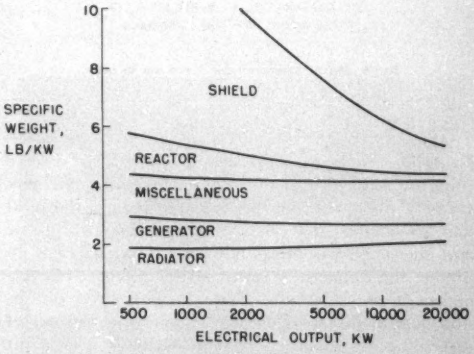


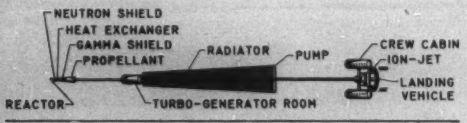
Fig. 5. Weight of power supply.

high-velocity impacts with correction for the density differences between meteoroids and the experimental particles suggests that several hundred days might pass without a penetration. This comparison shows the uncertainty in the meteoroid penetration picture.

To reduce the penetration suggested by Whipple's paper from 20 per day to 1 per 300 days would require an increase in the radiator weight to about 1 million pounds. This large value yields a specific powerplant weight of about 55 pounds per kilowatt rather than the value of 6 pounds per kilowatt for the 20-mw powerplant.

The major engineering challenge of the electric propulsion system is the radiator for elimination of the waste heat. It is running hot, above 1,800 R (Rankine). Its walls are thin and subject to meteoroid penetration. Puncture should be self-sealing. It must be compartmented and valved to protect against fluid loss on puncture. It is large—several hundred feet long and less than an inch thick. The liquid metal working fluid must be protected against corrosion and erosion difficulties. The liquid metal must not be allowed to freeze in the tubes. Hence, shutdown is not easy or convenient. Nevertheless proponents of electric propulsion are optimistic in their confidence that the difficulties can be overcome.

A space ship designed for an 8-man expedition to Mars[9] is shown in Fig. 6. The ship is shadow shielded from the reactor and, hence, the odd shape of the radiator and parts. The crew compartment is at the rear with the ion propulsion jet.



PAYLOAD FOR 8 MAN CREW	LB		
		LENGTH	600 FT
		GROSS WT	322,000 LB
10 LB/DAY/MAN	80,000	POWERPLANT WT	60,400 LB
CABINS	50,000	PROPELLANT	60,400 LB
LANDING VEHICLE	40,000	THRUST	32.2 LB
TOTAL	170,000	POWER	11 MW

EXPLORATION TIME AT MARS, 329 DAYS
TOTAL ROUND TRIP TIME, 1100 DAYS

Fig. 6. Electric spacecraft for round trip to Mars.

Other energy conversion schemes are of course interesting for generating electricity. Perhaps three deserve comment. The first is the magnetohydrodynamic generator. This device uses a plasma to replace the solid wire conductors in the magnetic field. Hence, turbine and rotating parts are eliminated. It is too early to predict the competitive status of this scheme. The second is the use of semiconductors to give direct conversion of heat to electricity.[4,10,11] Production versions of these units are about 5% efficient but there is hope for tripling this value. The semiconductors generally have rather low temperature cold wall junctions. Hence, the problem of radiating the waste heat is a major one. For this reason such devices are as yet of questionable value for primary propulsion.

Of much more interest is the plasma diode.[12,13,14] In this device, electrons are boiled off the hot plate and are condensed on the cold plate. Cesium vapor is between the plates to neutralize space charge and adjust the work functions of the electrodes. The developed voltage is 1 to 1.5 volts per cell. These devices can be built for very high temperature and reasonable efficiencies.

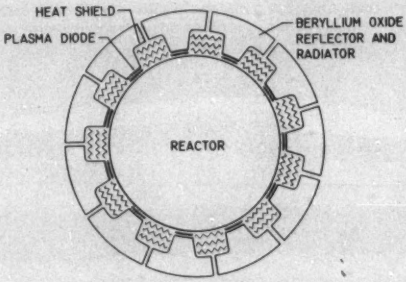


Fig. 7. A nuclear plasma diode electric plant.

Volney Wilson has suggested an interesting arrangement of plasma diodes on a reactor. Because of the problem of radiating the waste heat, the plasma diode cold-junction area must be bigger than the spherical surface of a reactor to generate the heat. He suggests the schematic arrangement of Fig. 7. This arrangement might well be competitive with the nuclear turboelectric system in the smaller sizes. The damage expected from meteoroids is also minimized as the beryllium reflector serves as a meteoroid shield. Conversion efficiencies on the order of 10% are anticipated for this arrangement taking into account the problem of radiating the waste heat to space. The plasma diode is, of course, basically capable of efficiencies perhaps twice this high.

ELECTRIC PROPULSION ACCELERATORS

MANY SCHEMES have been proposed for utilizing electricity to accelerate matter to speeds higher than the chemical rocket can sustain. These schemes may generally be grouped as follows according to the method of accelerating the jet:

1. *Ion accelerators.* Propulsion by means of charged particles that have been accelerated by electric (electrostatic) fields.

2. *Plasma accelerators.* Propulsion by means of a plasma that has been accelerated by combinations of electric and magnetic fields.

3. *Electrothermal accelerators.* Propulsion by means of a fluid that has been heated by electricity and is then

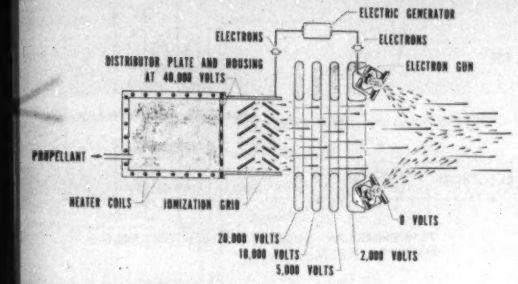


Fig. 8. Simplified diagram of ion rocket.

expanded through a more or less conventional supersonic nozzle.

These terms are by no means standard in the literature. Ion propulsion, for example, may refer in the jargon to any electromagnetic acceleration of ionized gases. Again Giannini[15] calls his arc-heated rocket a plasma jet; the latter is a prime example of electrothermal propulsion.

A major requirement of any electric rocket is that the jet remain neutral. If, for example, an ion propulsion device continued to send only positive ions out the jet, the ship would soon build up a voltage relative to that of space. This voltage would quickly be sufficient to slow down the ions and cancel the thrust. Ship neutrality in this case is maintained by blending an equal number of negative charges with the positive ion stream after its acceleration. The jet must thus be either a plasma or a neutral beam after it leaves the ship.

An equally important criterion is that all the particles be accelerated. If an ion source, for example, only ionized a fraction of the atoms in the jet and the unionized particles drifted at low speeds to the exhaust, a corresponding loss in specific impulse and efficiency would result.

Ion accelerators. An ion rocket contains a source for positive ions, a set of electrodes for accelerating the ions, and an electron source for neutralizing the beam following the acceleration. The intensity of the beam (current density) is generally limited by space charge according to the Langmuir-Childs relation[16]

$$i = 5.56 \times 10^{-12} \sqrt{\frac{e}{\mu}} \frac{V^{3/2}}{L^2} \qquad (10)$$

where

e/μ = the charge to mass ratio in coulombs per kilogram
V = the potential in volts
L = the distance from the ion source to the accelerator grid

This equation results because the electric field due to the ion cloud is opposed to the field resulting from the accelerating voltage. Thus, the current density increases with voltage and decreases with increasing accelerator grid spacing. To obtain higher current densities, it may thus be profitable to overaccelerate the ions, then decelerate them to the optimum impulse value. If the grids do not draw current, such a procedure would add to the power consumption. It also might decrease the beam divergence due to mutual charge repulsion.

Following release of the positive ions at optimum impulse and ground potential, electrons should be blended with the beam as soon as possible to neutralize the charge. The electron velocity should equal the ion velocity. The acceleration voltage of the electrons should, therefore, be smaller in proportion to the mass ratio than that of the positive ions. The mass ratio of an electron to a cesium atom is 4.12×10^{-6}. Hence, a 10,000 electron-volt cesium ion would have the same speed as a 0.04-volt electron. This low energy represents an electron at a temperature of only 4 F. As shown both by theory (Harold Mirels, unpublished) and by the experiments at Rocketdyne under the direction of Robert Boden, a positive ion beam will pull electrons out of a hot electron emitting grid without the further complication of electron acceleration grids according to the needs for neutralization. In fact, thermal electrons from a hot filament will generally have speeds higher than the positive ions that they should neutralize. David Langmuir has suggested that adverse potential oscillations may occur in the ion jet as a result.

The most commonly discussed ion source for electric propulsion is the cesium rocket shown in Fig. 8. Cesium

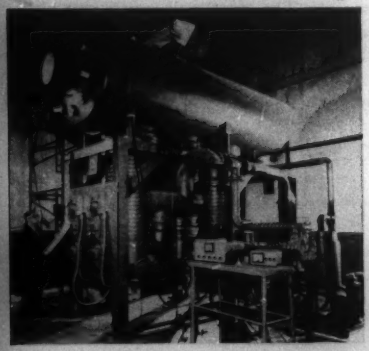


Fig. 9 (*left*). Ion rocket test facility.

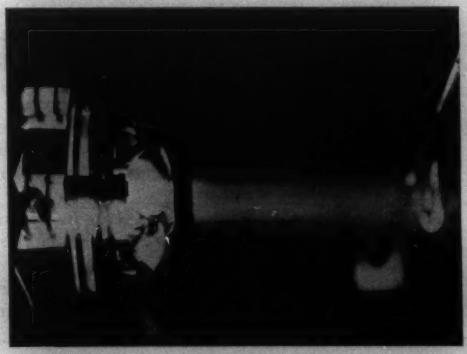


Fig. 10 (*right*). Ion rocket.

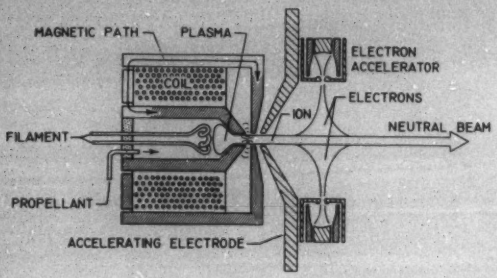


Fig. 11. Von Ardenne ion rocket.

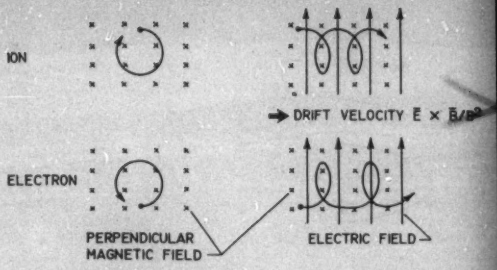


Fig. 12. Charged particle motions in magnetic and electric fields.

vapor is impinged on grids of hot tungsten or platinum. The ionization potential of the cesium is 3.87 volts, a value less than the work function required to remove an electron from the grid surface. Hence, each atom of cesium that comes into contact with the grid loses its electron and rebounds as an ion. The cesium ions are then accelerated by means of electric fields toward the exit where electrons are blended with the ion stream. The tungsten or platinum grid is kept hot to prevent cesium atoms from sticking. A layer of cesium atoms a few molecules thick will drastically reduce the work function of tungsten and render it ineffective as an ionization surface.

The contact ionization method for producing cesium ions has been recognized for some time.[17, 18] Stuhlinger[19] first suggested its application to electric propulsion. The cesium source is the most prominent of those that have been considered for ion propulsion. Ionization efficiencies of nearly 100% are obtainable with reasonable current densities. Experiments are being conducted at the Rocketdyne Corporation,[20] GE's Evendale plant,[21] NASA Lewis Research Center,[22] and other places to determine the potential of this accelerator.

Fig. 9 shows a view of the Lewis Research Center's vacuum facility for an investigation of a cesium motor of 0.1-pound thrust. The vacuum tank is 5 feet in diameter by 17 feet long with two 32-inch-diameter oil diffusion pumps attached along the lower periphery. In order to maintain the vacuum with the large cesium flow rates of the source, liquid-nitrogen-cooled baffles are installed to condense the gas from the cesium beam. Vacuum pressures of about 2×10^{-8} mm mercury are obtained in this facility.

Fig. 10 shows the cesium ion beam during early test operations. To obtain this time exposure, it was necessary to increase the tank pressure to give sufficient light from bombardment of the ambient gas molecules in the beam.

An ion accelerator may be adjusted to its optimum impulse by properly setting the acceleration voltage (within the limits of breakdown). The thrust per unit area, on the other hand is restrained by the Langmuir-Childs space charge limitation as may be derived from equation 10

$$\frac{T}{A} = 8 \times 10^{-13} \left(\frac{V}{L}\right)^2 \approx 1.8 \times 10^{-9} \left(\frac{\mu}{e}\right)^2 \frac{I^4}{L^2} \qquad (11)$$

Thus, if the optimum impulse is fixed by the mission, the thrust per unit area increases with the square of the mass-to-charge ratio. Hence, the desire for high molecular weight ions.

In order to obtain the highest thrust density, several investigations including those at Hughes Tool Company, Aerojet, and others are considering the charging of colloidal particles in place of the ion source. The limitation is that the required accelerator field strengths may remove the electron charge from the colloidal particles. If the particles can be made uniformly small without coagulation, then this course may prove to be effective.

Another potential ion source for electric propulsion is due to Von Ardenne.[23] This source (Fig. 11) utilizes an electric arc to ionize the jet. An intense mirror-like magnetic field is employed to confine the arc and increase the life of ionizing electrons therein. Both ionization effectiveness and beam current per unit area are quite favorable. As pointed out by John Luce of Oak Ridge National Laboratory, the electric arc deserves considerable attention as a potential source for intense ion beams.

Plasma accelerators. A current carrying element in a magnetic field is acted upon by a force at right angles to the current and the magnetic field. This is the principle of most motors. The current of course may either be induced by a changing magnetic field which generates an electric field or by an applied voltage. Thus, the force is generated by a combination of electric and magnetic fields.

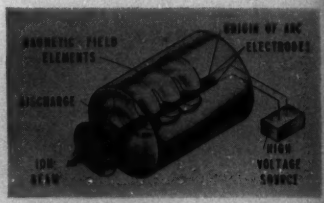


Fig. 13. Rail plasma accelerator.

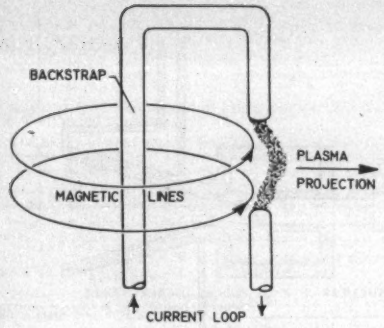


Fig. 14. Plasma projection using Kolb's backstrap.

Most forms of linear motors can serve as plasma accelerators if the usual current carrying element of the armature is replaced by a conducting plasma. A current can be generated by positive charges moving in one direction or negative charges moving in the opposite sense. As a result, both positive and negative charges move in the same average direction[1,24] with a drift velocity (Fig. 12) given by

$$\bar{v} = \frac{\bar{E} \times \bar{H}}{H^2} \tag{12}$$

This corresponds to the zero power or idling condition for a motor. If energy is to be added, the electric field vector must be tilted toward the direction of the desired acceleration.[25] In the plasma accelerators, positive and negative charges are propelled more or less together so that space charge neutralization may be unnecessary.

The rail accelerator (Fig. 13) shows a simple form of a plasma motor. An arc is struck between the rails at a narrowed gap. The plasma in this arc is propelled parallel to the rails until it blows off the end whereupon the arc restrikes at the narrowed gap.

If the arc current is high, the current along the rails generates its own magnetic field sufficient to propel the plasma. The most widely discussed accelerator utilizing this principle is the Bostick Button.[26,27] Specific impulses in the 10^4 range have been obtained. An axisymmetric arrangement based on a similar principle has also proved feasible.[28] The efficiency of such devices is as yet rather low.

Kolb[29] uses a backstrap arrangement to produce the self-induced magnetic field. His device is shown schematically in Fig. 14. Here again high impulses have been obtained but with low efficiency.

A plasma may be generated and projected by a rapidly changing magnetic field. A simple form of such a device is a single turn of wire subjected to a heavy surge of current (Fig. 15). The rate of change of the magnetic field generates a solenoidal electric field leading to breakdown and the formation of a current ring. The plasma in this current ring is propelled outward along the axis from the center. Prof. Bleakney and his co-workers at Princeton have utilized this method in their electric shock-tube research.

Others have effectively utilized the pinch effect to obtain extreme plasma projection speeds (Fig. 16). An arc is struck as a continuation of the center conductor of a coaxial cable. The confining magnetic field of the current carrying plasma plows the plasma toward the axis to give extreme pressure and temperature. The plasma squirts out through the hole on the axis. According to Smelt, Lockheed research workers have found this scheme several times as efficient as the Kolb backstrap.

A magnetic mirror[1, 24] may be used for trapping and projecting plasma. In a magnetic mirror (Fig. 17) the plasma is trapped in the trough of an axial magnetic field gradient. If the "mirror" is then shifted along its axis at a continuously increasing speed, the plasma will be accelerated accordingly as a surf board rides the waves.

Hansen and co-workers at Litton Industries, Clauser et al at Space Technology Laboratories, Post at Livermore and others have studied devices utilizing the magnetic mirror to project plasma. These early studies appear to be promising.

Plasma may also be propelled without discharge (Fig. 18). Sears and Resler[30] and others have made many contributions to both theory and experiment on these arcless $E \times H$ accelerators. As is the case of most electric accelerators they are not yet suitable for serious consideration for propulsion. The experimental studies of these and many other schemes[31] for propelling matter by electricity must await further development to get out of the research and development phase.

Electrothermal accelerators. Electric heating offers the possibility of obtaining gas temperature orders of magnitude higher than are available in chemical rockets. After heating, hot gas would be expanded through a more or less conventional nozzle—perhaps with a magnetic throat—and then exhausted to space. The arc-heated rocket (Fig. 19) can feasibly obtain specific im-

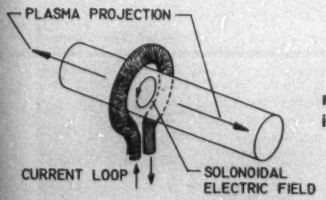


Fig. 15. Plasma projection by induction.

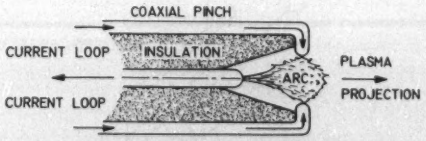


Fig. 16. Plasma projection via the pinch effect.

pulses up to about 3,000 or 4,000. Thus, this device might find interesting use for missions whose specific impulses optimize in this range. Many laboratories across the country are developing arc-heated jets following pioneering work in Germany.[32-35]

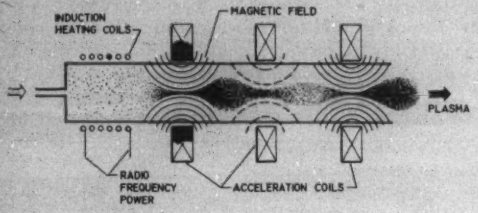


Fig. 17. Magnetic mirror plasma rocket.

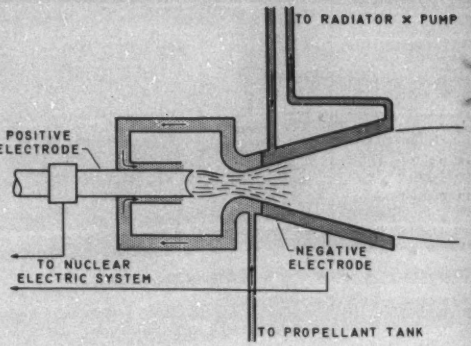


Fig. 19. Arc-jet propulsion system.

R-f heating is also being examined. In this device, theory suggests that the r-f heating may hold the plasma off the walls from an a-c pinch effect. While extreme impulses may be obtained with the device, the weight of the associated electric equipment might be too large for a space ship.

With respect to all electrothermal accelerators, it should be noted that solar or nuclear fission heat is converted to electricity with an efficiency of no greater than 20%. This electricity is then converted back to heat in the accelerator. If the resulting specific impulse is high enough, the inefficiency associated with the conversion processes can be tolerated because of the decrease in propellant weight. On the other hand, if the optimum impulse of the mission is low—say, in the range of 1,000—then surely the nuclear rocket utilizing the heat directly would yield a better system. The reactor would be smaller—the radiator problem would be eliminated and the simplicity and dependability would be greater.

CONCLUDING REMARKS

THE FIRST APPLICATION of electric propulsion is perhaps 5 years away. It will likely be utilized for orbital guidance and vehicle orientation control or for 1-way space probes. The electric power level will be low—perhaps less than 100 kw. Electric propulsion is also of considerable interest for lifting large payload fractions from low to high altitude orbits. Manned space journeys via electric propulsion must await the development of large booster systems. Perhaps 10 to 20 years will elapse before manned electric space craft in the several megawatt range are feasible.

The greatest uncertainty in the potentialities of electric propulsion are caused by the uncertainties in the space environment. Intense meteoroid damage probabilities or intense transient solar or cosmic radiations can adversely affect the prognosticated future of most space propulsion systems. Considerable importance and urgency is therefore attached to the scientific satellites designed to study the space environment.

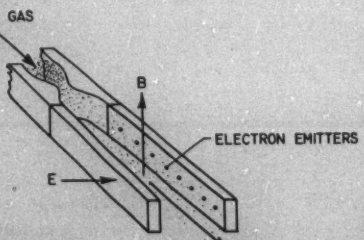


Fig. 18. $E \times B$ accelerator.

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Crossing to "Right" Side of Tracks

An atomic reactor, born in Philadelphia on the "wrong" side of the tracks, crossed over on the morning of May 1, at 2:00 a.m. and tied up eight lanes of the Pennsylvania Rail Road (PRR) main line for an hour and a half.

Constructed in the Eddystone, Pa., shops of the Baldwin-Lima-Hamilton Corporation (BLH), the atomic hardware was too big to pass under the tracks through a 9½-foot tunnel which permits normal traffic at the plant to cross the railroad which traverses the BLH property at Eddystone.

Built in the form of two giant stainless steel cylinders, the reactor had to cross the tracks to be placed on a barge at the BLH wharf on the Delaware River to begin a 45-day trip by inland waterway and an 80-mile trailer haul to Hallam, Nebr. There, the cylinders will become the main structure for a civilian atomic power plant to be operated by the Nebraska Power Authority.

One cylinder is 21 feet in diameter, 36 feet long, and weighs 65 tons; the other, of slightly thicker steel, is 19 feet in diameter, 33 feet long, and weighs 85 tons. Each cylinder is worth about $250,000.

The cylinders could not be built on the wharf (or "right") side of the tracks because the special shop equipment needed to build them to the precise dimensions required was located on the other side of the tracks.

When it came time to move the cylinders, BLH could take no chances that the carefully shaped cylinders would be thrown out of kilter by, say, a fast freight or an early morning express. At one point, "sky hooks"—actually heavy-duty helicopters—were considered. The plan was to use three or four helicopters working in unison to lift and carry the cylinders across the tracks. But the cylinders were too heavy for complete safety, so helicopters were ruled out.

BLH engineers got together with PRR officials and determined that, if proper preparations were made, the cylinders could be taken across the tracks in less than 15 minutes. To do so, however, weeks of advance preparations were necessary and an additional 1½ hours was needed to raise and lower high-tension lines that power commuter trains serving the Philadelphia area.

BLH built a special steel skid for each cylinder. The cylinders were bolted to the skids and placed on multi-axled flatbed trailers operated by Headley's Express, heavy hauling contractors of Chester, Pa. The trailers carried the cylinders across the tracks. Two miles of road were built to give the trailers a smooth path to and away from the tracks at the point of crossing.

Transient Current Decay in Paralleled Rectifiers

W. R. HODGSON
MEMBER AIEE

THE ADVENT of silicon semiconductor rectifier applications to large electrochemical lines has developed application problems heretofore not significant. The majority of existing potlines have mercury-arc rectifiers as a source of d-c power. In general a single a-c breaker will feed the entire potline rectifier group. Load tests in the field have been made which show that the most satisfactory method of removing a rectifier line from service is to trip the master a-c breaker, removing a-c power simultaneously from all units. The potline current will then decay through the mercury-arc tubes and the rectifier transformers, dividing between paralleled units.

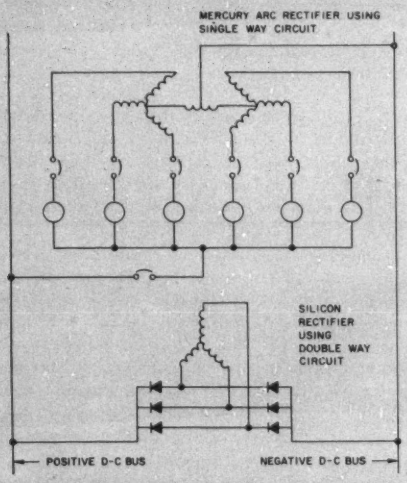
MERCURY ARC RECTIFIER USING SINGLE WAY CIRCUIT
SILICON RECTIFIER USING DOUBLE WAY CIRCUIT
POSITIVE D-C BUS
NEGATIVE D-C BUS

Fig. 1. A 6-phase double-Y single-way mercury-arc rectifier circuit and 6-phase Y double-way silicon rectifier d-c circuits.

The situation with regard to removing a-c power is somewhat changed when a silicon unit is paralleled on the bus with a number of mercury-arc units. This is because a 6-phase double-way circuit is used with a silicon rectifier whereas a 6-phase double-Y single-way circuit is used on the mercury arc. Reference to Fig. 1 will show the difference in the circuit. The mercury-arc rectifier has transformer winding impedances in series with the tubes, while the silicon rectifier cells with its double-way circuit is connected directly between the d-c busses.

The equivalent circuit for the d-c system is shown in Fig. 2. For the purpose of the analysis it was determined that a compound RL circuit exists. The switching operation takes place at time $t = 0$ and an analysis was made to investigate the current at subsequent times during the transient period.

The differential equation which applies is $Ri + L\,di/dt = 0$. This must, however, be modified because of back emf (electromotive force) of the cells and because parallel paths exist as shown in the simplified circuit diagram. Therefore, two simultaneous loop equations resulted.

A program was then carried out on a differential analyzer which proved capable of predicting the currents that a silicon rectifier must handle when operating in parallel with the mercury-arc rectifiers during the transient phenomena associated with master trip of the a-c breakers. The effect of various parameters on the magnitude of current handled by the silicon rectifier was studied.

On a given potline, the back emf, the inductance, resistance, and current rating of the potline are fixed parameters. Therefore, the amount of potline discharge current can be predicted, once the rating and physical configuration of the silicon rectifier unit are determined.

The proper placement on a potline bus may be predicted to give impedance values of the silicon branch to obtain currents within the capabilities of the cells being used. Thus, assurance can be obtained that the silicon rectifier unit can handle the potline discharge current satisfactorily.

With the program as followed, the study provided sufficient data to assist in analysis of current division between parallel mercury-arc rectifiers and silicon rectifiers during the transient phenomena associated with potline decay.

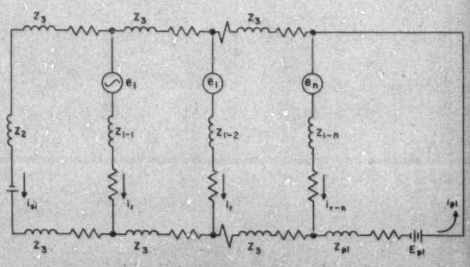

Fig. 2. Equivalent circuit d-c system.

Digest of paper 60-36, "Transient Decay of Current Through Paralleled Mercury-Arc and Silicon Rectifiers," recommended by the AIEE Industrial Power Rectifiers Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960. Published in AIEE *Applications and Industry*, May 1960, pp. 70-75.

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The Measurement of Temperature in Welding Arcs

H. C. LUDWIG

An improved technique for determining the temperature distribution in arc discharge has been developed. By use of this method, a direct record may be obtained from the spectral intensities and the need for a photographic record is eliminated.

KNOWLEDGE of the temperature distribution within the arc plasma is necessary for determining its energy transport properties. These properties are interrelated to the irreversible processes of radiation, convection, diffusion, and conduction which vary with the temperature and composition of the plasma. Problems are being encountered in arc welding research which require a more thorough understanding of the thermal energy transport in the arc plasma.

An established welding arc is a type of thermionic phenomenon. Upon initiation it transforms from a short-lived low-temperature glow discharge to a discharge of very high temperature. Its attained thermal state is controlled by a balance in the simultaneous production and loss of electrically conducting particles.

The temperatures attained in welding arcs vary considerably according to the composition of the plasma and the power input. The maximum temperature in low-current arcs (less than 100 amperes), for example, iron electrodes in air, is about 6,000 K (degrees Kelvin).[1] In tungsten-electrode arcs shielded by helium or argon, however, the maximum temperature may be as high as 30,000 K. The highest temperatures realized thus far in welding arcs have been attained by making use of currents greater than 100 amperes conducted through inert gas environments. Although these temperatures greatly exceed those required to melt the base metal, the welding speed, which is a function of the rate of heat transport to the welding zone, is increased due to a higher thermal energy state attained in the arc plasma. Thus, the measurement of temperatures attained in welding arcs is desired for practical as well as scientific reasons.

Several basic findings by Saha,[2-3] Boltzmann,[4] Compton,[5] and others[6-10] have preceded the development of techniques for measuring the extremely high temperatures of arcs and chemical flames. The temperature of a gas is represented by a Boltzmann distribution of the energy taken up by the particles present.[4] The energy in arcs is absorbed by the particles in translational, rotational, or vibrational states as energy of excitation, ionization, and radiation. It has been established by the control of the thermal behavior of electric arcs that temperature equilibrium, i.e., equally in the temperature of ions, electrons, and neutral atoms, is closely approached or attained particularly at pressures of 1 atmosphere or higher.[5-9] It has also been found that the emission from the plasma of an electric arc is representative of the temperature of the gas, provided no self-absorption of the radiation occurs. Saha[2] extended the Law of Mass Action to include the dissociation of polyatomic gases; also, the excitation and ionization of all gases. It is from the Saha Equation of Thermal Ionization that particle density of electrons, ions, and atoms can be calculated for any given pressure. It is upon the knowledge of the composition of the arc plasma that a basis for temperature measurements can be made. At a pressure of 1 atmosphere, some 10^{17} to 10^{18} particles per cubic centimeter are present. These consist of electrons, ions, and atoms.

From the work of Fowler and Milne,[9,10] the variation in the intensity of thermally excited spectral emission lines was determined through astrophysical observations. Their findings led to the conception of temperature measurement techniques for man-made arcs based on several different types of spectroscopic observations. The method of temperature measurement to be described here is due essentially to Larenz[11] and Bartels.[12,13] It is based upon using intensities of spectral lines as thermometers. The selection of various spectral lines representing the quantized emission of the gas being thermally excited in the plasma is made according to the range of temperature being measured. Spectral emission due to excited atoms is generally selected for the lowest temperature found in arcs, whereas emission due to singly and doubly ionized atoms is utilized for the higher temperatures. Certain improvements in technique and instrumentation have been made which eliminate the need for photographic records of the spectral radiation used in the prior method for the measurement of line intensities. The work described here involves the measurement of the temperature distribution in the tungsten electrode–argon gas arc widely employed in the welding industry.

COMPOSITION OF THE ARC PLASMA

THE DEPENDENCE of the degree of ionization upon temperature in a thermally excited gas can be deter-

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mined according to the Law of Mass Action,

$$\frac{n_+ n_e}{n_0} = f(T) \tag{1}$$

where n_+, n_e, and n_0 are particle densities or ions, electrons, and atoms, respectively. The ionization equilibrium as a function of temperature was developed by Saha according to the following equation:

$$\frac{n_+ n_e}{n_0} = \frac{U_+}{U_0} \frac{2(2\pi mkT)^{\frac{3}{2}}}{h^3} \exp\left(\frac{-E_i}{kT}\right) \tag{2}$$

where U_+ and U_0 = the partition function for ions and atoms.

U_+ and U_0 = the partition function for ions and atoms
m = mass of the electron
k = Boltzmann's constant
h = Planck's constant
E_i = energy of ionization or excitation

The particle densities of ions, electrons, and atoms may be determined through the simultaneous solution of equations 1, 2, and the following equations 3 and 4.

$$n_e = n_+ \tag{3}$$

The total free charge in the case of thermal ionization is zero and

$$n_e + n_+ + n_0 = n_{\text{total}} \tag{4}$$

where n_{total} is the total particle density. The pressure as a function of temperature is determined from the Ideal Gas Law

$$P = (n_+ + n_e + n_0)kT \tag{5}$$

The particle densities of ions, electrons, and atoms in thermally excited argon as a function of temperature[14] are shown in the semilogarithmic graph of Fig. 1. At any given temperature, the composition of the gas is shown in kind and quantity.

APPLICATION OF EMISSION SPECTROSCOPY TO TEMPERATURE MEASUREMENT

THE EMISSION from a stable electric arc represents a steady-state radiation of the transitions which the various excited and ionized particles undergo as the result of gain and loss of thermal energy. In the return to a state of lower energy than that attained, radiation is emitted which corresponds to the temperature of the particle. Thus, the emitted radiation, when properly resolved and measured, acts as a thermometer in measuring temperatures. Fowler and Milne, among others, derived the relationship between the intensity of a thermally excited spectral line and temperature. If the particle density of a certain excited level is given by Boltzmann's law and if the emission is from an optically thin layer, i.e., no self-absorption occurs, then

$$I_{\text{absolute}} = \frac{A}{4\pi} h\gamma \frac{g_a}{z_0} n_0 \exp\left(\frac{-E_i}{kT}\right) \tag{6}$$

where

I_{absolute} = intensity of light emitted in 1 cubic centimeter
A = transition probability of the energy to the ground state
$\frac{g_a}{z_0}$ = partition function
γ = frequency of the emitted radiation
n_0 = particle density of atoms in the ground state

For a given spectral line the variables in equation 5 are n_0 and temperature T, so

$$I_{\text{relative}} \sim n_0 \exp\left(\frac{-E_i}{kT}\right) \tag{7}$$

By varying the temperature for a given excitation po-

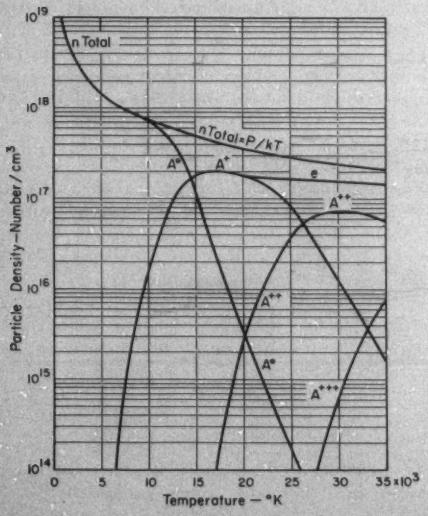

Fig. 1 (left). Argon-arc plasma composition, at a pressure of 1 atmosphere.[14]

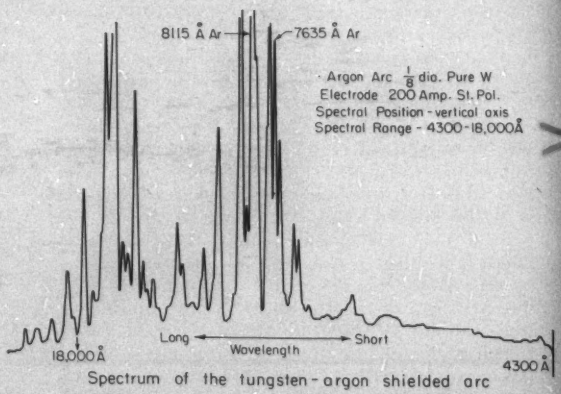

Fig. 2 (above). Spectrum of the tungsten argon-shielded arc.

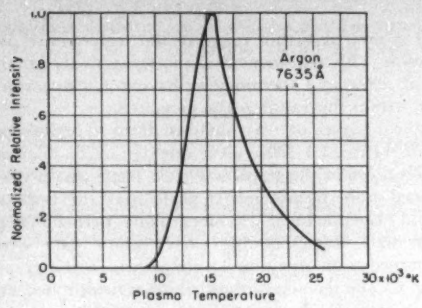

Fig. 3. Intensity as a function of temperature.

tential E_i and using the corresponding neutral atom particle density calculated from the Saha equation,[2] the proportionality shown in equation 7 can be determined. We now have a relation for the spectral line intensity as a function of temperature corresponding to a given excitation potential. For the determination of temperature in the tungsten argon-shielded arc, the argon spectral line 7,635 Angstrom units was chosen. This emission comes about through an energy transition from 13.17 electron volts to the ground state corresponding to a wave number of 106,237.6 cm^{-1}. The spectrum of the plasma of a tungsten argon-shielded arc shows lines of neutral and singly ionized atoms. A typical spectrum obtained using a recording spectrometer is shown in Fig. 2. The proportionality indicated in equation 7 is shown graphically in Fig. 3 where temperature is plotted on the abscissa and relative intensity normalized to unity for the maximum value is shown on the ordinate. In analyzing the curve of Fig. 3, one can observe that in plotting exponential function $\exp(-E_i/kT)$ against temperature, unity is approached while the particle density of neutral atoms decreases as the temperature increases (Fig. 1). As a result, the curve of Fig. 3 has a maximum at a certain temperature. The consequence of the intensity of a spectral line having a maximum value corresponding to a certain temperature represents a standard upon which the measurement of extremely high temperatures can be based.

SIGNIFICANCE OF SPECTRAL LINE INTENSITY MEASUREMENTS

THE MEASUREMENT of the spectral line intensities is obtained through the thickness of the arc plasma as it varies from the axis radially outward to the boundary. These data must be resolved so as to obtain the local point intensity along the radius of the arc plasma. To obtain the local point intensity as a function of the radius, certain assumptions are made. It is assumed that the plasma is symmetrical about its axis and that the temperature falls from a maximum value at the axis to the arc boundary. The intensity of the spectral line as a function of the arc radius $i(r)$ is obtained from the experimentally determined values of intensity $i(x)$ through a 2-step mathematical process[15] of (1) a differentiation of each experimental curve, and (2) an integration to be described. The experimental values $i(x)$, assuming no absorption, are expressed as

$$i(x) = \sum_{-y_0}^{+y_0} i(r) \cdot \Delta y \tag{8}$$

when considering, from Fig. 4, a section through the arc plasma where z is the vertical axis and $\Delta z \Delta x$ is the cross section of a small volume element. For symmetrical geometry

$$i(x) = 2 \int_0^{y_0} i(r) dy \tag{9}$$

If one replaces y with r as an independent variable, then

$$i(x) = 2 \int_x^{r_0} \frac{i(r) r dr}{\sqrt{r^2 - x^2}} \tag{10}$$

The values $i(r)$ are determined by differentiating $i(x)$ and rearranging for the solution

$$i(r) = -\frac{1}{\pi} \int_r^{r_0} \frac{i(x)' \, dx}{\sqrt{r^2 - x^2}} \tag{11}$$

Equation 11 is a so-called Abel integral equation. These mathematical processes must be carried out numerically. The use of a digital computing machine greatly facilitates the work.

The temperature as a function of the arc plasma radius $T(r)$, i.e., the temperature distribution, is obtained from a cross-plot of the curve of the spectral line intensity as a function of the radius $i(r)$ and the line intensity as a function of temperature, $i(T)$, calculated from equation 7. It is necessary that a maximum occurs in the curve of line intensity as a function of the radius corresponding to the maximum value obtained in the curve of equation 7 as shown in Fig. 3. Thus, a fixed

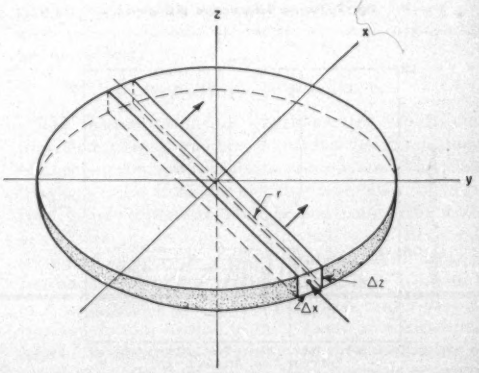

Fig. 4. Cross section through the arc plasma, showing the orientation of a volume element.

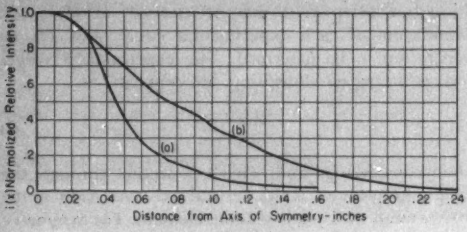

Fig. 5. Center-boundary variation of intensity of argon (7,635 Angstrom units).

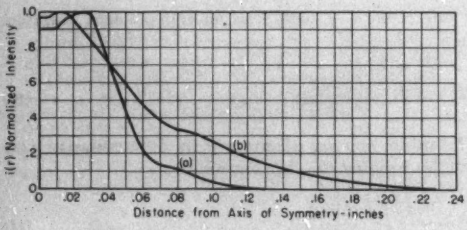

Fig. 6. Intensity as a function of arc radius.

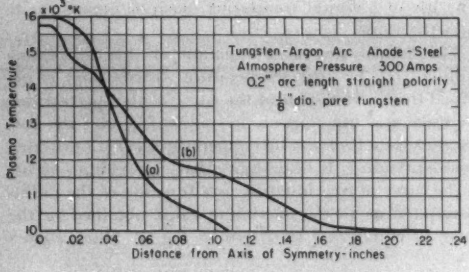

Fig. 7. Plasma temperature distribution.

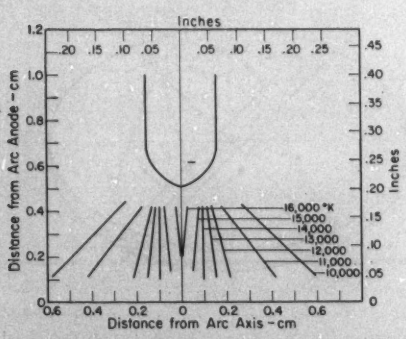

Fig. 8. Temperature distribution in an argon–tungsten arc at 300 amperes.

point is secured within range of the temperature distribution. This requirement is analogous to the condition of selecting a thermometer having a temperature range within the values to be measured.

Typical curves of $i(x)$ obtained from experimental measurements of a 300-ampere tungsten argon-shielded arc are shown in the graph of Fig. 5. These curves were obtained from measurements made near the cathode (*a*) and near the anode (*b*) along planes perpendicular to the axis. Corresponding curves whose data were determined from equation 11 are shown in the graph of Fig. 6. The temperature distribution determined for the locations in the plasma described are shown in the graph of Fig. 7. Isotemperature curves for the tungsten-electrode argon-shielded arc are shown in the graph of Fig. 8.

THE TECHNIQUE AND EXPERIMENTAL PROCEDURE

IN THE EXPERIMENTAL TECHNIQUE to be described, the spectral intensity variation from the center to the boundary of the arc plasma is measured by using automatically recording devices instead of a photographic process. In addition to the need of dark room facilities, photographic records of the spectra require corrections for nonlinear response of blackening to the variations in spectral line intensity.

The spectroscopic method described here makes use of a recording spectrometer of the monochromator type equipped with a light chopper and a quartz prism using single-pass optics. The receptor is a vacuum thermocouple. Provision has been made to use a photomultiplier tube to serve also as a receptor. The chopped signal is amplified as an alternating signal and converted to a unidirectional signal by synchronized breakers. The amplified unidirectional signal is fed to a high-speed null-type potentiometer recorder. In obtaining the spectral line intensity variation from the center of the arc plasma to the boundary, the spectrometer is set to receive the wavelength of light corresponding to the chosen spectral line.

The image of the arc magnified several times is focused at the slit of the spectrometer and caused to scan across the slit at a constant rate. The record obtained on the high-speed recorder represents the spectral line intensity variation from one side of the arc to the other. The results obtained can at once be analyzed for geometric symmetry. Knowing the speed of the drive of the recorder, the rate for which the image of arc is scanned across the slit and magnification of the arc, one can obtain the required lineal measurement of the distance from the center to the boundary of the arc. After normalization of the data obtained from the recorded curves, one proceeds as described previously.

CONCLUSION

AN IMPROVED TECHNIQUE for determining the temperature distribution in symmetrical and optically thin arc discharges has been developed based on a method described by Larenz and others. The improved technique makes use of instrumentation from which one

obtains a direct record of the spectral line intensities. The need for a photographic record has been eliminated.

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Progress and Problems in World Communication

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FELLOW AIEE

Among the problems related to world-wide communication discussed in the second part of this article are the length factor, transmission delay, distortion, noise, switching, and signaling.

Part II

WE CAN SEE in the offing a veritable legion of new electronic techniques and devices. But it is now time to consider how the waxing demands for world communication and the burgeoning constituent techniques will affect over-all planning and performance requirements. Any attempt herein to specify precise requirements would indeed be foolhardy. Suffice it to set forth certain general observations, leaving the exact specifications as an exercise for those skilled in the art.

Perhaps the simplest place to start is with the critical factor of maximum length. In North America it has been generally accepted thus far that the maximum length for any type of intracontinental circuit might be assumed not to exceed about 4,000 miles. In Europe, something like 1,500 miles has been a corresponding guide for international circuits. For world communication a new look is needed. Despite the present importance of economic factors, it would seem prudent to plan for a future maximum length of at least 10,000 miles, perhaps more. Come what may, communication circuits will necessarily deviate from great circle routes.

The inevitable increase in length will influence all other requirements. Increased distance means increased transmission time. At least it is fortunate that high-speed carrier transmission over cable or radio can provide the circuits which will form the backbone of the world-wide network. Increased distance also means, in all probability, more switches and more carrier-to-baseband translations. For these and other reasons, increased length will intensify, sometimes to a major degree, the transmission problems we have coped with for many years.

TRANSMISSION DELAY

THE FACTORS of greater length, greater transmission time, and a larger number of switches and translations react importantly on telephone transmission. One problem here stems from the fact that telephone conversation, by its very nature, must be practically instantaneous. Even on existing continental voice networks, transmission delay is a major problem. With present systems, the delay due to the medium itself is about 6 to 8 milliseconds per 1,000 miles. Each carrier-to-voice translation adds to this, as do a number of incidental factors. With reasonable limitation on the number of translations, the total one-way delay, even on a 10,000-mile circuit, can probably be limited to about 100 milliseconds, which means an equivalent transmission

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speed about one-half that of light. This figure of 100 milliseconds should be compared with the present CCITT (Telegraph and Telephone) limit of 50 milliseconds on national networks and 150 milliseconds for a chain of international networks. Parenthetically, a one-way delay, from all sources, of 250 milliseconds is about the maximum permissible in commercial telephony.

With transmission delays of such magnitude, echoes would be intolerable without echo suppressors. In fact, with the impedance irregularities now prevalent, echo suppressors are desirable on all circuits having a one-way delay of more than 20 to 25 milliseconds. For world-wide telephone communication, some way will have to be found to use echo suppressors as needed for intracontinental connections while still avoiding serious degradation from tandem echo suppressors on intercontinental circuits.

Four-wire long distance switching will be important. If all the main switching points of the world-wide network can be tied together by carrier trunks, with four-wire switching and with few or no translations to voice except at switching points, echo and other problems can probably be kept under control.

TELEPHONE DISTORTION, NOISE, AND CROSSTALK

VOICE COMMUNICATION is extremely vulnerable to distortion in the amplitude–frequency transmission characteristic, and also to nonlinear distortion, but much less so to delay distortion. Generally speaking, one telephone circuit occupies such a small fraction of the bandwidth afforded by the transmission medium that the amplitude and delay distortion on main routes is contributed almost entirely by the equipment at the translating points. In this matter the CCIF (Telephone) has already played a very farsighted role. Largely through its efforts, telephone administrations generally have adopted a 4-kc spacing for carrier telephone channels. This makes it possible to keep distortion within satisfactory limits, even for a substantial number of switching points with carrier-to-voice translation.

On submarine cables, because of immediate traffic demands and economic factors, use is being made of 3-kc spacing and, in some cases, even 2-kc spacing. As the length of telephone connections and number of links increase, the 4-kc standard spacing will become increasingly desirable for major cable routes.

Noise and crosstalk, both of which are usually a function of distance, constitute another serious problem on long intercontinental circuits. International agreement on suitable over-all limits will be essential, together with careful control of the component contributions at levels well below those existing today. One favorable factor in this situation is the accumulating evidence that as transmission performance improves, talker volumes tend to go down. Advantage can be taken of this to increase transmitting gain and reduce receiving gain.

TRANSMISSION VARIATIONS AND RELIABILITY

DESPITE the most stringent efforts to limit the number of switching links and the number of translations between voice and carrier, some increase in these numbers seems inevitable as international communications grow and alternate routing practices are extended. The increased number of switches not only will aggravate most of the telephone transmission problems already mentioned, but also will make it necessary to preserve very close limits on the net loss of the individual links. Clearly an integrated switching plan will be needed to reduce the number of switches, reduce voice-to-carrier translation, make most effective use of four-wire switching, and reduce the unfavorable effects of tandem echo suppressors.

Furthermore, in this exacting tomorrow, present maintenance methods will become inadequate. Reliability will be increasingly important and must be freed from the tyranny of increasing numbers of components and devices. Automatic measuring devices will be required for constant monitoring of transmission performance, and automatic means for correcting the inevitable changes so as to assure adequate end-to-end transmission. Automatic means for sectionalizing trouble and restoring service will also be needed.

END LINKS–TELEPHONE INSTRUMENTS

IT IS NATURAL, in discussing world-wide communication, to center attention on long international circuits. It would be a mistake, however, to overlook the part played by the terminal links and especially the customer's telephone set and loop connection. The telephone transmitter is the chief source of nonlinear distortion in a telephone call. The transmitter or receiver may contribute to transmission degradation through inadequate control of the gain–frequency characteristic. Moreover, it is the reflection due to the impedance irregularity introduced by the station set that is the main cause of echo and net loss problems. And finally, the customer's loop is often the principal source of noise.

There seems to be less international agreement on objectives for station sets and loops for any other part of the circuit. Because sets and loops occur in such large numbers, major emphasis has been on cost reduction rather than transmission improvement. Amplification is obtained so cheaply in the carbon transmitter that the accompanying distortion is condoned. Similarly, the need for maximum efficiency at minimum cost in receivers has led to the use of highly reactive instruments which provide a poor termination to telephone lines. Transistors may afford a new freedom in telephone set design that will ultimately correct this situation. In any case, the neglected end link offers challenging opportunities for improvement in world telephone communication.

WORLD-WIDE AUTOMATIC SWITCHING

OVER most of the world, enormous strides are being made in the automatic switching of national and international long distance calls, under the control of

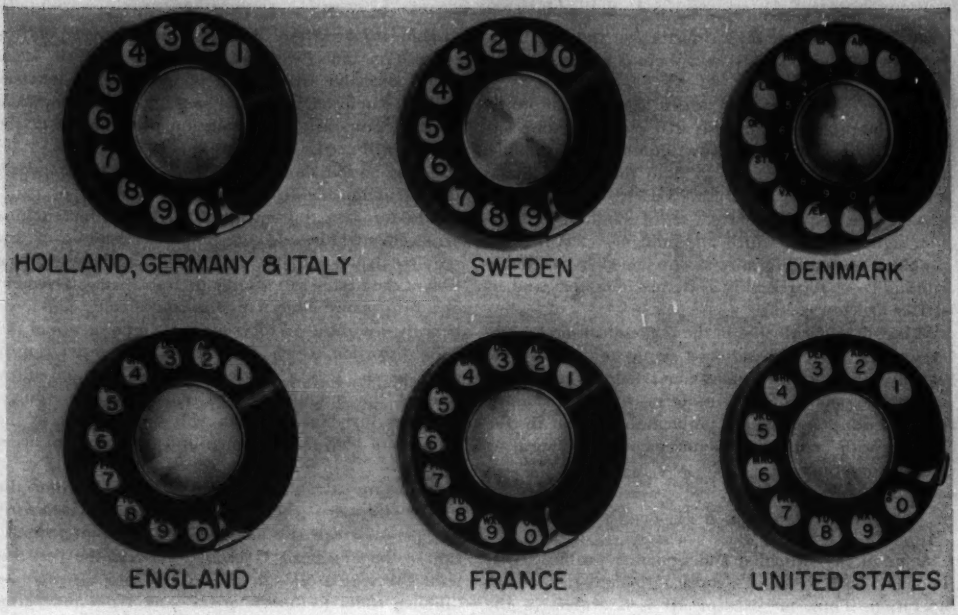

Fig. 10. Telephone dials.

dialing by either operators or customers. These developments clearly presage the advent of automatic switching of intercontinental calls. However, many difficult problems remain to be solved in the continental networks, and even more knotty ones for the global case.

Some of the global switching problems are primarily technical; others involve both technical and nontechnical considerations. An important technical problem is the lack of a standard dial. Fig. 10 shows a few of the different arrangements used in Europe and the United States. Difficulties are fairly obvious. In the United States, for example, the letter "O" corresponds to the numeral six; in the United Kingdom to the numeral zero. Hence operators or equipment must do a translation on office codes using the letter O. Differences in alphabets, as for instance in the Danish dial, suggest that it will be necessary to go to all-numeral codes before customers can dial intercontinental calls. Even then the Swedish dial will present a problem because its numerals run from zero to 9 instead of the more usual 1 to zero. Too, there are other difficulties, both technical and economic, involved in customer dialing of intercontinental calls.

Global automatic switching will in due course encounter a situation of serious proportions arising from the lack of a world-wide numbering plan. Existing continental numbering plans are running out of capacity. Apart from capacity, a world plan will have to provide for calling several types of operators, preferably on a universal basis for test and maintenance calling, and for other special needs. There will be questions of whether a fixed or variable number of digits should be used, and what the maximum digit capacity should be. Compatibility between push-button sets and dials will also need to be considered.

SIGNALING PROBLEMS

World-wide automatic switching involves still other problems having to do with signaling arrangements, i.e., the means whereby supervisory and control information is made available at both ends of a connection, as well as at intermediate switching points. At present, the electrical language used to transmit such signaling information differs between countries, and even within countries. In the past, progress has been made in Europe and North America on the standardization of signaling arrangements which are, unfortunately, dissimilar for the two continents. Now, with dialing over the transatlantic cables imminent, co-ordination between continents has become essential.

This co-ordination involves such things as the kinds of information required, the frequencies used, the duration and power level of the signals, the use of simple or compound signal combinations, the speed of connection, and the reliability of service. The problem is further complicated by the Tasi equipment, which requires an elongated initial signal to seize a channel, and spurt signals of appropriate length to assure chan-

nel continuity without overloading. While arrangements that are reasonably satisfactory for the time being have already been worked out, there is plenty of room for future progress.

Another signaling area where greater uniformity should be promptly sought is that of information signals (i.e., line busy, paths busy, number not available, trouble encountered, etc.). In both the United States and Europe there is a confusing variety of such signals. It would be helpful to have a set of standard information signals toward which all could move. Still other problems of nonuniformity are presented by the methods and codes for reaching assistance operators, and by service and test codes.

A broader difficulty lies in the various technical repercussions of what is basically a nontechnical problem, namely, differences in language and dialect. This affects not only operators and customers, but also maintenance personnel. Language problems also occur in connection with recorded announcements for indicating special conditions.

OTHER SWITCHING AND RELATED PROBLEMS

Some of the switching and signaling problems that lie ahead have to do with intracontinental methods of operation. Thus, for example, it is desirable, in the interest of greater flexibility and higher switching speed, that major switching centers in each international network employ common control with digit storage and translation. Again, it will probably become important, in the interest of efficiency, to operate at least some international trunks on a two-way basis, with dialing instead of ring down operation.

Maximum usage of alternate routing is desirable both within and between continents. Each major center dealing with intercontinental calls should be able to act as a switching point to other countries. Related to alternate routing is the matter of revenue settlements between different administrations. A multilateral arrangement for international operations, similar to the United States pooling scheme, is desirable to keep revenue settlements from becoming a stumbling block to effective alternate routing.

Technical problems are aggravated also by lack of uniformity in service offerings (e.g., person-to-person, collect, credit card, etc.) and diversity of rates. Rates which facilitate automatic recording of charges are essential.

DATA COMMUNICATION

In view of multiplying demands for various forms of data communication and the growing need for compatibility between transmission links and terminal gear, co-ordination in this field on a world-wide basis will assume increasing importance. Much of the data will be at low speed, corresponding to the rate of human generation and utilization. Higher speeds will be needed, however, for more efficient use of communication channels, as well as for direct machine-to-machine conversation. Although nonswitched point-to-point data links will continue to be used, it seems highly probable that the telephone switched network will be employed more and more for handling data. For this purpose the transmission performance of the circuits will need to be improved.

Consideration should soon be given to the standardization of an adequate and economical set of bandwidths for data transmission, together with switching arrangements for selecting interoffice trunks of the required bandwidth for each connection. Standardization of data rates will also be desirable, and agreement on performance objectives for transmission links, especially for those factors, such as impulse noise and delay distortion, which affect data signals more seriously than speech. Also, a reasonable degree of standardization of the modulating and demodulating arrangements at the data terminals will be desirable in the interests of both the customers and the communication carriers.

Important advantages would also result from the standardization of codes. Lack of such standardization has already given rise to difficulty in the interconnection of the European Telex network and the Bell System TWX network. Because these two systems use different codes (although of the same type) and different bit rates, translation and storage must be provided at interconnection points.

Related to the matter of codes is the subject of accuracy in data transmission. Although almost all telegraph communication is now carried on without special means for error correction, there is evidence that, in the future, error correction either by detection and partial retransmission or by means of self-correcting codes will be needed for many applications of data transmission. A collateral consideration is whether the transmission channel should be half or full duplex so as to permit the return of an indication to the transmitter in case of an error.

Standardized signaling and supervisory arrangements will likewise be desirable for a world-wide data system. The concept of a common switching network suggests the need for a common language to enable stations to talk to switching centers and switching centers to talk to one another. Dial pulse signaling and electromechanical switching speeds are not in good time balance with the short messages typical of some forms of data transmission.

TELEVISION

Television across the ocean is bound to come, although the extent to which economic justification will be found is still somewhat problematical. Problems of language differences and time differences will be worked out somehow. World-wide standardization of television signals, while desirable, seems quite impracticable; conversion from one kind of signal to another will take care of the situation. For the present, bandwidth across

the ocean is a serious problem. However, improved transoceanic media will be available in a few years. Band compression techniques of one kind or another can, if necessary, be used at a sacrifice of quality.

MILITARY COMMUNICATION

BECAUSE OF THE NEED for far-flung control of military organizations and operations, global communication for military purposes is today assuming special importance. Such communication requires all sorts of interlinkages and involves all kinds of signals—aural, visual, pictorial, telegraphic, high-speed digital, etc.—with stringent requirements on speed, reliability and security. In some measure these needs will be met by special military networks. However, interrelations with the commercial facilities are inevitable, and these will be greatly facilitated by advance co-ordination and standardization.

CONCLUSION

HERE we must conclude. If it has been made to appear that the future path of world communication lies through thorns as well as roses, this has not been accidental. We must not, we dare not, ignore the difficulties. Rather should we be mindful of Samuel Johnson's dictum that "life affords no higher pleasure than that of surmounting difficulties."

If emphasis has been placed upon the need for a high level of international co-operation and standardization in solving the problems of world communication, this has been based on deep conviction. And based, too, upon a strong sense, indeed a vision, of the vital role that the International Telecommunication Union and the CCI's can and must play in this co-operative effort.

If urgency has been stressed, this merely reflects an uneasy feeling that we may be dancing on top of a technological volcano.

Finally, it may be apropos to suggest the existence of a basic relation between world communication and world peace. The relation may be merely this, that honest communication begets understanding, and that understanding is a necessary though not sufficient condition for harmonious life.

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The Gravy Train Again

(This is a brief follow-up to "The Gravy Train," which appears in the May 1960 issue of *Electrical Engineering*, p. 406.)

Bore a hole through the side of the pipe, exposing one set of wires. Push the train along until the magnet is lined up with the peephole. Looking in, we see the wires. Looking between them, we see the end of one magnet pole. Let the spiral pitch be such that we see the wires crossing the magnet axle and the pipe axis at 45 degrees. This is the simplest case to analyze. Turn on the current.

The magnetic field of the pole acts on the current in the wires. A force acts on the wires, normal to them. This force is at 45 degrees to the pipe axis. An opposing force, also at 45 degrees, acts on the pole. Let this force, referred to the radius at the end of the pole, be one pound. This force resolves into two components: 0.707 pound at right angles to the pipe axis, and 0.707 pound parallel to that axis. If the bar magnet is 2 feet long, the forces of the two poles across the axis produce a turning torque total of 1.414 pound-feet.

The torque is transmitted through the gear train to the cogwheels. They push against the track teeth and attempt to start the train. Unfortunately, the force components on the poles parallel to the pipe axis, amounting to 1.414 pounds, act backwards, and precisely balance the forward thrust obtained by way of torque. Any other spiral angle will also come out with balanced forward-and-back forces.

The Gravy Train will not run. But there *are* stresses in the gear train.

A. D. MOORE (F '43)

Conductor Economics for EHV Transmission

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THE USE OF bundle conductors for power transmission was first proposed by P. H. Thomas in 1909. The electrical characteristics of bundle conductors were then recognized to be superior in many respects to the characteristics of comparable single conductors. However, it was also known at that time that bundle conductors had higher initial costs and a more complex mechanical structure than single conductors. Therefore, no significant applications of this new concept were made in the next 40 years, although in 1931 C. A. Boddie proposed a 500-kv line with four conductors in a bundle. As a result of extensive investigations made in the last 10 years of the electrical and mechanical characteristics of bundle conductors, many transmission lines have been and are being built all over the world utilizing this type of construction.

At present, extra-high-voltage transmission lines (voltages of 275 kv and above) use one, two, three, and four conductors per phase. It is not clear, therefore, what the optimum configuration of future extra-high-voltage lines will be. In fact, it will depend most probably upon the system characteristics, cost data, and also upon the willingness of the utility management to try out new types of construction. For these reasons, in planning the General Electric Extra-High-Voltage (EHV) Project it has been decided to investigate one, two, and three conductors per phase at 460 kv, and three and four conductors per phase at 650 kv.

OPTIMUM CONFIGURATIONS

IN ORDER to determine the optimum configurations and cross section for the various test conditions of the Project EHV line, an economic study was initiated in 1957 by the authors, inasmuch as no criteria were available in the literature at that time.

A digital computer program has been prepared for the IBM (International Business Machines Corporation) *705* data-processing machine, with the following objective:

> "To determine the optimum configuration and cross section of extra-high-voltage lines (345 kv and above), as a function of all the parameters having economic significance."

In order to obtain a fair comparison of the relative economics of using one, two, three, or four conductors per phase for a given transmission line, it is necessary to compare alternative solutions using the same assumptions for all cases. In the program all operating and investment costs, evaluated at an appropriate rate, are added up in order to determine the total annual charges for each configuration. By varying the cross section over an appropriate range, the optimum cross section, corresponding to minimum cost, may be determined for each line configuration. Then the individual optimums are compared to establish the over-all optimum bundling configuration for a given circuit loading. All important factors in which bundle and single conductors differ are taken into account in the program, according to criteria which evaluate the annual cost of each factor. The range of the economic evaluation of certain factors is quite extensive, depending upon the requirements of the system considered, the cost structure involved, and other considerations. It is then necessary to study the effect of varying these factors on the over-all results.

SYSTEMS INVESTIGATED

THE SYSTEMS investigated consist of a generating station with step-up transformation supplying a subtransmission load bus through the transmission system and receiving-end step-down transformation. Series-capacitor compensation was assumed to be 40 and 50 per cent at distances of 250 and 500 miles, respectively. At 100 miles, zero series capacitor compensation was assumed, but transformer impedances and transformer costs were varied to compensate for the differences in line reactances for the various bundle configurations.

The following system parameters are used to present the results of this study:

1. Distance (100, 250, and 500 miles)
2. Transmission voltage level (345, 460, and 650 kv)
3. Load factor (50 and 80 per cent)
4. Loading per circuit (depending upon distance and voltage)

RESULTS

THE RESULTS of this investigation are presented in the form of annual cost differentials with respect to an arbitrarily selected base configuration, as a function of the total conductor cross section per phase and line configuration. It is concluded that these cost differentials may be quite important, both if expressed in dollars or in percentage of the total annual cost. Each system, however, must be investigated on its own merits, according to the method advanced here, in order to determine its optimum configuration.

Digest of paper 60-53, "Economics of Single and Bundle Conductors for Extra-High-Voltage Transmission," recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960. Published in AIEE *Power Apparatus and Systems*, June 1960, pp. 138-53.

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Solid-Rotor Synchronous Machine—Part II

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THE ANALYSIS of solid-rotor synchronous machines presented previously[1] is extended in three ways: (1) by expressing the results of the analysis in a more convenient form; (2) by presenting additional numerical results; and (3) by outlining a new analytical attack.

1. The present effort gives the same performance equations as in reference 1, written in terms of the widely used direct- and quadrature-axis components of the 2-reaction theory of synchronous machines,[2] introducing the concepts of operational impedances of that theory. For the new equations, reference should be made to the paper itself.

2. Numerical results are presented to show examples of: (a) The effect of air-gap curvature on the calculated torque-slip characteristics; (b) The standstill direct- and quadrature-axis impedances; (c) The negative-phase-sequence resistance; (d) The induced field current produced by a 3-phase armature terminal short circuit; and (e) The damping torque coefficient for small oscillations of the rotor about a normal synchronous operating point.

Fig. 1 shows the effect of air-gap curvature on the torque-slip curve for a typical machine.

3. The extension of the previous analysis consists in taking into account the radial space distribution of the field winding in the rotor. Equations for the machine impedances are developed. While these seem to be too complicated for direct use in a transient response, they can be evaluated relatively easily for any rotor frequency. Thus, the frequency response of the system now can be determined and compared to that given by the previous analysis.

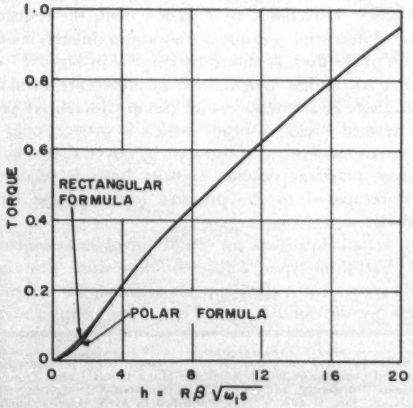

Fig. 1. Effect of air-gap curvature on the torque-slip curve for a typical machine.

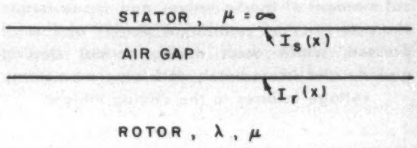

Fig. 2. Representation of the physical system used in analysis of reference 1.

Fig. 2 shows the representation of the physical system used in the previous analysis, while Fig. 3 shows the representation used in the new analysis.

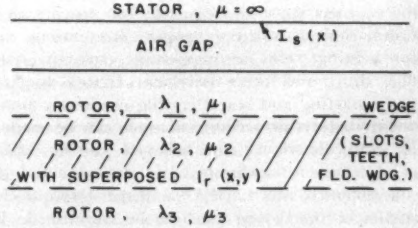

Fig. 3. Representation of the physical system used in the new analysis.

The principal conclusions drawn are: (1) The performance equations for a solid-rotor machine can be expressed in the same form as those of an ideal synchronous machine; (2) The effect of air-gap curvature is very small; (3) Rotor resistance cannot be neglected in calculating subtransient impedance; (4) A large solid-rotor generator has a relatively high damping torque; (5) A new analysis, taking into account more realistically the actual rotor and rotor-winding configuration, has been developed. The resulting equations are amenable to evaluation by frequency-response techniques.

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Centrifugal Pump and Compressor Characteristics

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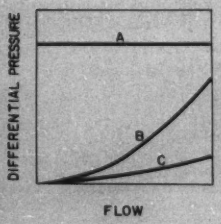
This article presents, in general terms, the typical moment of inertia values and speed-torque characteristics of centrifugal pumps and compressors which occur during normal starting periods and immediately following momentary voltage failures to the driving motors.

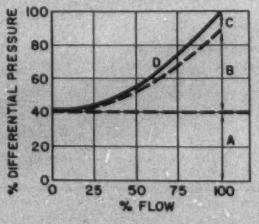
THE BEHAVIOR of electric motor drivers under transient conditions is presenting an increasing number of problems to electrical engineers in the refining industry. The problems are compounded as larger machines are installed and as continuity of service through momentary voltage failures becomes more important to process operation.

The motor designer and the refinery electrical application engineer are most frequently concerned with the determination of starting torque, accelerating time, motor heating, relay settings, surge currents, system voltage drop, and other pertinent factors associated with the starting and reaccelerating of electric motors. However, before an accurate analysis can be made of motor and electric system behavior during various types of transient conditions, it is often essential that the movement of inertia (WK^2) and speed–torque characteristics of the driven machine be established. The WK^2 of a particular machine usually can be learned from the manufacturer, but speed–torque characteristics for various types of fluid and mechanical systems often require a more arduous investigation. Although the problems of starting large motors have been emphasized in recent literature, the intimately related subjects of pump and compressor characteristics which affect the motor driver usually have been ignored or oversimplified.



A — *Static head*
B — *Friction loss*

Fig. 1. System pressure–flow characteristics.



C — *Velocity head*
D — *Composite characteristics*

Fig. 2. Composite liquid system characteristics.

PUMPS AND LIQUID SYSTEMS

Liquid System Characteristics. In order to establish the torque requirement of a pump at any particular instant, it is necessary to know certain characteristics of the liquid system in which it is operating. Fundamentally, these characteristics take the form of differential pressure across the pump as a function of liquid flow through the pump.

For a system in which a pump transfers liquid from one elevation to a higher elevation, and in which pipe friction and velocity head are negligible, the required pump differential pressure is essentially constant at all rates of flow, as illustrated by curve *A* of Fig. 1. The difference in elevation is termed "static head" and may be converted to differential pressure in pounds per square inch by calculating the weight of a column of the liquid 1 inch square having the same height as the difference in elevation. In some cases, an effective static head exists where a pump works in a system with a controlled back pressure, such as a system with a receiver maintained at constant pressure. A pump feeding water to a boiler steam drum is a familiar example of a system with back pressure controlled at a constant value.

In a system where liquid is transferred from one location to another at the same elevation and in which velocity head is negligible, the difference in pressure between the two locations is solely a result of friction from the liquid acting against the pipe, fittings, valves, and other restrictions. In such a system, the required pump differential pressure varies approximately as the square of the flow, as shown by curve *B* in Fig. 1.

In a frictionless system with no difference in static head, there is a component of pump differential pressure termed "velocity head" which is proportional to the square of flow, as illustrated by curve *C* in Fig. 1. In most practical systems, velocity head is relatively small compared to the pressure loss resulting from friction.

An actual liquid system usually involves a combination of all three types of differential pressure. The composite system curve then appears as shown for a typical system by the solid line in Fig. 2. For simplification,

Essentially full text of paper 60-16, "Characteristics of Centrifugal Pumps and Compressors Which Affect the Motor Driver Under Transient Conditions," presented at the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960. Published in AIEE *Applications and Industry*, July 1960.

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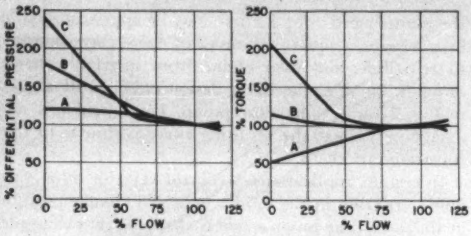


A — Radial-flow pump, specific speed = 1,000 rpm
B — Mixed-flow pump, specific speed = 5,500 rpm
C — Axial-flow pump, specific speed = 10,000 rpm

Fig. 3. Pressure–flow and torque–flow characteristics of centrifugal pumps at rated speed.

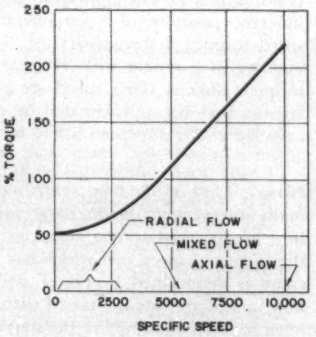


Fig. 4. No-load torque at rated speed for centrifugal pumps having various specific speeds.

friction and velocity head will be combined hereafter into one characteristic curve which varies as the square of flow and which will be called "friction head." Specific systems will be identified by the percentage of static head compared to the total differential pressure at design flow (100% flow). For example, the composite curve *D* in Fig. 2 will be called a system with 40% static head.

Frequently, the flow in a liquid system fed by a centrifugal pump is controlled by means of a variable restriction in the piping, usually a control valve. A system will have different over-all characteristics for each different position of the variable restriction, as shown by the dashed lines in Fig. 9 for a typical system with 40% static head.

When the liquid in a long full line is first accelerated by starting a pump or rapidly opening a valve, the inertia of the liquid may momentarily cause the system to appear to have a closed discharge valve.

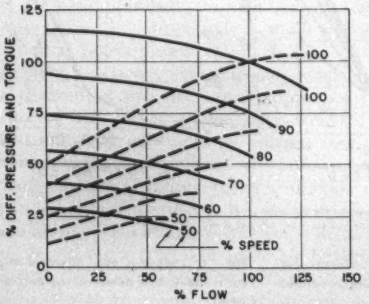
Pump WK^2. The inertia values for a variety of centrifugal pumps cannot be shown conveniently by curves or tables. In general, however, the WK^2 of a motor driver is several times as great as the pump to which it is connected. Therefore, accuracy in determining pump WK^2 is not usually a critical factor. Exact pump WK^2 values can be learned from the manufacturer.

Pump Characteristics. Typical constant-speed characteristics of differential pressure and torque as a function of flow are shown for three different types of pumps in Fig. 3. These three types, commonly called radial-flow, mixed-flow, and axial-flow pumps, can be classified by a term known as "specific speed."

Fig. 4 illustrates typical values of torque at zero flow and 100% speed for pumps having various specific speeds. For any individual pump, accurate characteristic curves furnished by the manufacturer show differential pressure (or head) and brake horsepower as a function of flow at design speed. Torque, which is directly proportional to horsepower and inversely proportional to speed, may be readily calculated for any given horsepower and speed.

In order to determine approximate pump characteristics at any speed other than rated speed, affinity laws may be used within reasonable limits. Typical torque and differential pressure characteristics as a function of flow for a radial-flow pump operating at various speeds are illustrated in Fig. 5.

Combined Pump and System Characteristics. In order to determine torque under any given set of conditions, the liquid system characteristic curve is plotted on the same co-ordinates as the variable-speed pump pressure-flow curves, as shown in Fig. 6. Then for any particular speed, the corresponding flow may be determined from the intersection of the appropriate system and pump

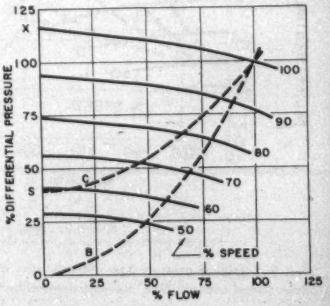


◄ **Fig. 5. Pressure and torque characteristics for a radial-flow pump operating at different speeds.**

Solid lines — Differential pressure
Dashed lines — Torque

► **Fig. 6. Radial-flow pump and system characteristics.**

Solid lines — Pump differential pressure
B — System pressure with 0% static head
C — System pressure with 40% static head



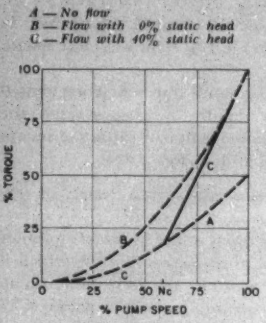


Fig. 7. Speed-torque characteristics for a radial-flow pump.

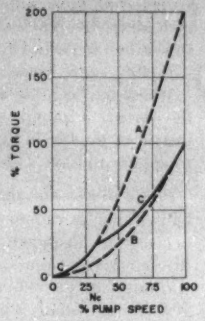


Fig. 8. Speed-torque characteristics for an axial-flow pump.

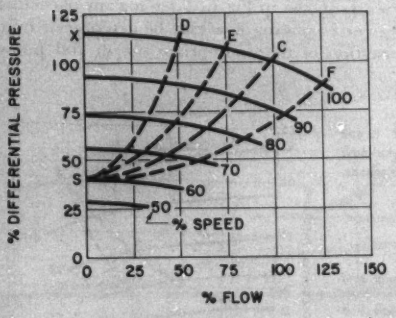
curves. If flow at one particular speed is known, the corresponding torque may be determined from the torque–flow curve corresponding to that speed as shown by the dashed lines in Fig. 5. By plotting a series of such torque values at several different speeds, a pump speed–torque curve may be derived.

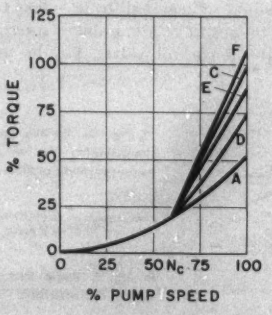
For no-flow conditions and for flow in a system with 0% static head, pump torque is directly proportional to the square of speed as shown by dashed lines *A* and *B* in Fig. 7. However, where static head is greater than 0%, the curve becomes more complex, with a marked change in slope at the speed where flow begins, as shown by solid line *C* in Fig. 7. In all cases described here, the pump is assumed to have a check valve in the discharge piping so that flow can not reverse direction.

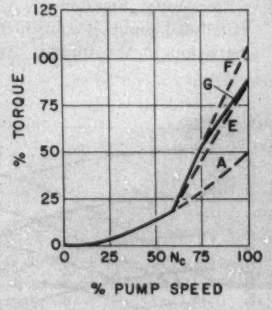
The per-unit speed where flow begins, N_c, is equal to $\sqrt{s/x}$, where s is the per-cent static head of the system and x is the per-cent pump differential pressure at zero flow and 100% speed. The points s and x are identified on the characteristic curves in Fig. 6. If N_c is known, the pump speed–torque curve may be approximated by first drawing a square relationship curve corresponding to zero flow, and then a line from speed N_c on the zero-flow curve to the 100% design point, as illustrated in Fig. 7 for a radial-flow pump. For mixed-flow and axial-flow pumps, the resulting curve is similar to that illustrated in Fig. 8.

In certain applications, a control valve or other variable restriction in the fluid system will change position at the same time pump speed is changing. For example, a control valve instrumented to maintain constant flow will open as the pump slows down, in attempting to maintain the desired flow rate. Different positions of a variable restriction produce a family of system characteristic curves as shown by the dashed lines in Fig. 9, wherein each system curve is identified by the corresponding flow at 100% pump speed. Fig. 10 shows how different positions of a variable restriction affect the speed–torque characteristics of a radial-flow pump working in a system with 40% static head. If known torque values at 100% speed are plotted these characteristics may be approximated by eye, since all curves coincide at N_c, the speed where flow begins.

Pump Torque Characteristics during Transient Conditions. Most radial-flow centrifugal pumps are normally started with the discharge valve closed, resulting in a pump speed–torque characteristic which varies as the square of speed and which has a full speed–torque value as determined by Fig. 4. Mixed-flow and axial-flow pumps are usually started with the discharge valve open in order to minimize the starting torque required. To determine starting speed–torque characteristics of these pumps when static head is greater than zero, it is necessary to plot the system and pump curves as described previously. The inertia of the liquid in a long full line may increase the starting torque requirements of mixed-flow and axial-flow pumps by making the system appear to have a closed or partially closed discharge valve.







A — *No flow* *D* — *System at 50% flow* *F* — *System at 125% flow*
C — *System at 100% flow* *E* — *System at 75% flow* *G* — *System when control valve is opening*

Fig. 9. Combined pressure-flow characteristics for a radial-flow pump and variable liquid system with 40% static head.

Fig. 10. Speed-flow characteristics for a radial-flow pump operating in various systems.

Fig. 11. Speed-torque characteristics for a radial-flow pump during deceleration.

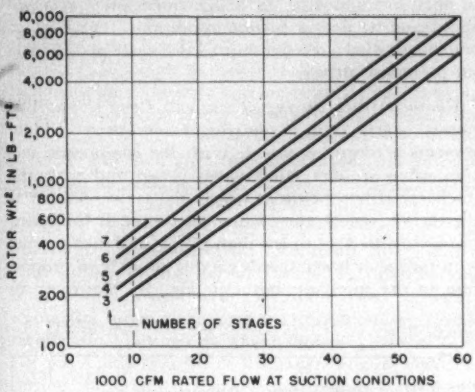


Fig. 12. Typical WK^2 values for centrifugal compressors.

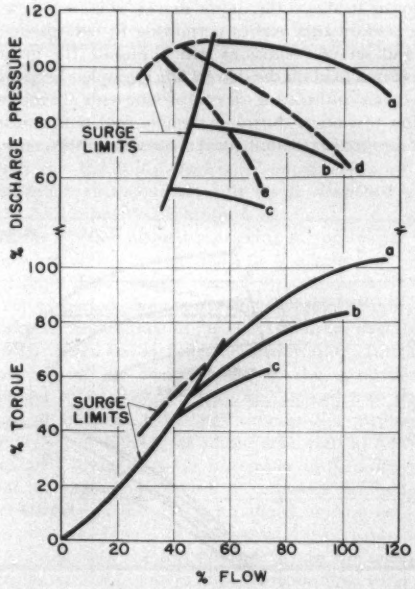
The calculation of speed–torque characteristics of all types of pumps during momentary power failures may require plotting the system and pump curves. For example, assume the case of a radial-flow pump and a system whose characteristics are illustrated by Figs. 5 and 9. Assume that under normal conditions the system curve is as shown for 75% of the design flow and that when electric power fails the control valve opens wide in a known length of time, changing the system curve to that shown as 125% of design flow. The speed–torque curve for the decelerating phase of the momentary failure will be as shown by the solid line in Fig. 11, the portion of the curve identified as G representing the period that the control valve is moving from the 75% position to the 125% position. When the motor is re-energized, the pump speed–torque curve will be as shown for 125% of design flow, since the control valve will likely remain fully open until the machine has returned to 100% speed.

COMPRESSORS AND GAS SYSTEMS

Gas System Characteristics. Two types of gas systems are commonly associated with centrifugal compressors in refineries. In a simple compression system, suction and discharge pressures remain nearly constant for various flow rates, since only a small portion of the differential pressure results from friction. In a circulating system, suction pressure usually remains constant, but differential pressure varies approximately as the square of flow under normal operation. During transient conditions, the discharge pressure in a gas system will not change as rapidly as will pressure in a liquid system, the rate of change being a function of the system volume and the means by which system pressure is maintained. For example, the gas systems associated with catalytic cracking unit main air blowers and gas concentration unit compressors have relatively large capacities and are operated at comparatively constant suction and discharge pressures. In these systems, pressure changes are relatively small during most transient conditions. A contrasting system is that exemplified by a recycle gas compressor in a catalytic reforming unit where the relative system capacity is low and there is no control equipment attempting to maintain a fixed pressure at the discharge of the compressor. In this type of recirculating system, pressure change can be significant within a few seconds. For the purpose of this article, gas systems will be described only as to whether the compressor discharge pressure changes slowly or rapidly during transient conditions.

Compressor WK^2. Typical values of WK^2 for centrifugal compressors are shown in Fig. 12. Since most motor-driven centrifugal compressors are connected to the driver through a speed increaser, the effective inertia of a compressor referred to the motor shaft must be determined by multiplying the compressor WK^2 by the square of the ratio of compressor speed to motor speed. In order to obtain total load WK^2, the inertia of the gear unit and couplings (referred to the motor shaft) must be added to the effective inertia of the compressor.

Compressor Characteristics during Steady-State Conditions. Typical pressure–flow and torque–flow performance curves for a centrifugal compressor with fixed suction conditions are shown in Fig. 13. The solid lines



Solid lines — Unthrottled characteristics at various speeds: a—100%, b—90%, c—80%
Dashed lines — Throttle characteristics at 100% speed

Fig. 13. Centrifugal compressor pressure and torque characteristics.

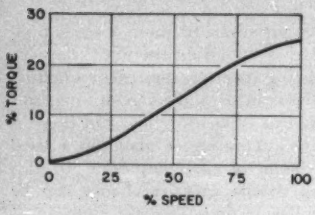
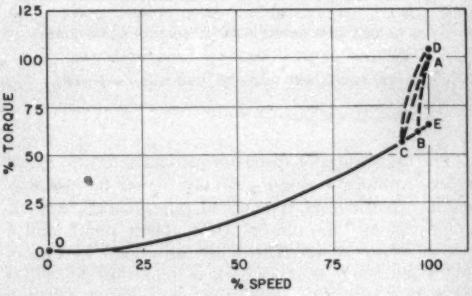


Fig. 14. Starting torque characteristics with closed guide vanes.

represent unthrottled performance at various speeds *a*, *b*, and *c*. The characteristics are discontinued for flow less than approximately 50% of design flow because unstable or surging operation occurs in this range. With suction throttling, such as the use of inlet guide vanes, the operating range can be extended as shown by the dashed lines. Lines *d* and *e* represent characterstics based on two different positions of the guide vanes at a constant compressor speed corresponding to curve *a*. Normally centrifugal compressor performance curves for various speeds may be obtained from the manufacturer. If only the rated-speed curves are available, the unthrottled pressure and torque characteristics at other than rated speeds can be approximated.

The discharge pressure developed by a compressor at constant flow and constant speed varies widely, depending upon the nature of the gas at suction conditions. Therefore, in analyzing transient compressor behavior as it affects the motor driver, it is best to work from performance curves pertaining to that particular gas and set of conditions which impose the greatest anticipated load on the driver. For example, the greatest load on an unthrottled air compressor with atmospheric suction will occur during extremely cold temperatures. The compressor manufacturer considers 100% torque as that corresponding to design horsepower at rated speed and at design suction conditions. There is, of course, no direct relationship to the name-plate rating on the motor driver.

Characteristics during Transient Conditions. The normal starting of a centrifugal compressor seldom presents a torque problem. With the compressor suction valve or inlet guide vanes closed and with the discharge system being at nearly the same pressure as the suction system, the compressor torque at full speed can usually be kept to less than 25% of full-load torque, with torque at lower speeds varying roughly in proportion to the speed as shown in Fig. 14. However, an analysis of the torque requirements during momentary power failures usually demands a more rigorous investigation, as described by the following examples:



EBCO — No flow
ABCO — Discharge system pressure constant at 100%
ACO — Discharge system pressure decreasing during deceleration
DCO — Discharge system pressure constant at 90%

Fig. 16. Unthrottled compressor speed—torque characteristics for various system conditions.

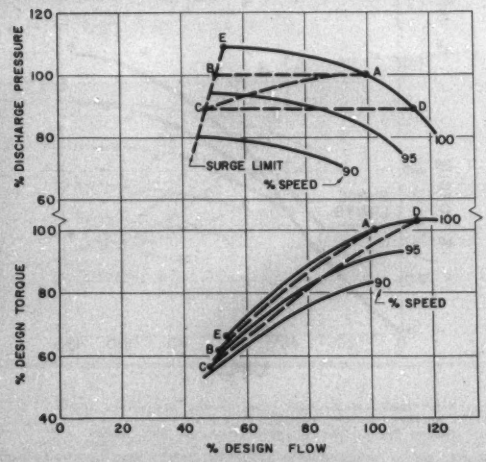


Fig. 15. Unthrottled compressor characteristics at various speeds.

Fig. 15 describes pressure and torque at various speeds plotted against flow of an unthrottled compressor. Assume that the unit is operating at its rating, point *A*, when the voltage to the motor driver fails. If the pressure remains relatively constant during the decelerating period, the compressor operation will follow the path identified by line *AB*. At *B* the surge range is entered, and soon after passing the surge limit, the compressor will not be able to develop enough discharge pressure to force gas into the system. The discharge check valve, therefore, will close and cause the compressor to operate at a no-flow condition. Torque characteristics at no-flow conditions and elsewhere in the surge range are subject to some speculation, since prolonged testing may mechanically damage the compressor and the rapidly fluctuating conditions are difficult to record with conventional instrumentation. For the sake of simplification, it can be assumed that torque at the surge line is identical to that at no-flow for any one speed. It can be further assumed that no-flow torque varies as the square of the speed,

with the full-speed torque being that shown as point *E*. On this basis, the no-flow speed–torque curve will be shown by solid line *EBCO* in Fig. 16. The actual values probably lie somewhat below the curve as shown but lack of accurate test data and conservatism suggest using this plot. Referring to Fig. 16, upon voltage failure the speed drops quickly from operating point *A* to no-flow point *B*, and then more and more slowly toward complete rest at point *O*.

If the gas system is such that the discharge pressure decreases rapidly when the machine decelerates, the operation of an unthrottled compressor will follow a path similar to line *AC* in Fig. 15. In this case, the compressor will decelerate to a lower speed before entering the surge range, and the corresponding speed–torque curve assumes the shape shown by line *ACO* in Fig. 16. A situation where discharge pressure decreases during the transient period may require a trial-and-error or step-by-step solution in order to establish the rate of change in compressor speed and system discharge pressure, since these two factors may be mutually dependent.

When the motor driving a centrifugal compressor is re-energized following a momentary voltage interruption, the compressor speed–torque curve during the accelerating period will be similar to that described for the decelerating period if discharge pressure has not changed. The curve will differ, however, if a substantial decrease in discharge pressure takes place during the momentary voltage failure. Dashed line *CD* in Fig. 15 shows the pressure–flow plot, assuming that the discharge pressure has decreased to 90% of normal and will remain at this level during the entire reaccelerating period. At 90% pressure, flow at full speed will increase to approximately 115%. Line *OCD* in Fig. 16 illustrates the resulting speed–torque characteristics for the accelerating period.

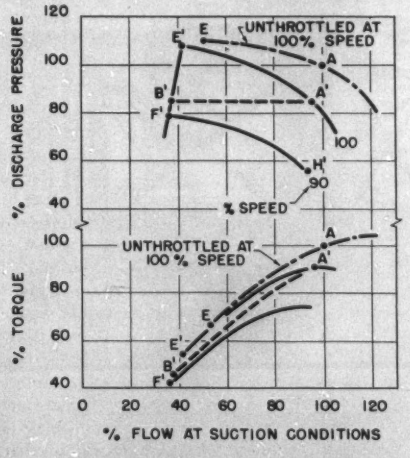
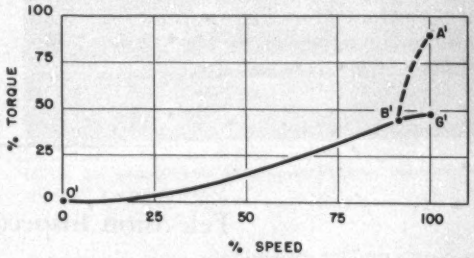


Fig. 17. Compressor characteristics at various speeds for one typical position of the suction throttling device.

Characteristics with Suction Throttling. In many constant-speed compressor applications, the flow is controlled by means of a damper, valve, or set of guide vanes located on the suction side of the compressor. The effect of such a variable restriction is the lowering of gas pressure at the compressor intake which, in turn, reduces the weight flow of gas and the discharge pressure. A suction throttling device affects the speed–torque characteristics of a centrifugal compressor during transient conditions in various ways, depending upon its speed of travel and how it is arranged for operation during power failures.

If electric power fails to the compressor motor, but the instruments and automatic operator which control the suction throttling device remain operative, the device will probably open wider when the compressor



O'B'A' — Discharge-system pressure constant at 85%, partial throttling
O'B'G' — Discharge-system pressure constant, closed throttling device

Fig. 18. Throttled compressor speed–torque characteristics.

decelerates, attempting to maintain constant gas flow. When the throttling device is completely open, the compressor characteristics will be as described previously for unthrottled machines.

If the suction throttling device maintains its position when electric power fails, or if it moves so slowly that there is only slight change in position during the transient period, the compressor characteristics will be similar to those shown in Fig. 17. The usual unthrottled characteristics are shown as dash-dot lines. Instead of operating at the design point *A*, the compressor is assumed to be partially throttled in order to run at point *A'*. Because of the large amount of throttling, the compressor is capable of stable operation at flows less than those limited by the normal or unthrottled surge limit. Pressure–flow curve *E'A'* estimates the full-speed performance of the unit with the throttling device in one position. Line *F'H'* represents the performance at 90% speed with the throttling device in the same position. Line *E'B'F'* traces the corresponding surge line at various speeds. Upon momentary voltage failure to the motor driver, the compressor loses speed rapidly and, assuming a discharge pressure which remains relatively unchanged, the flow decreases from *A'* to *B'* as speed drops from 100% to 92%. The torque during

this transition period is represented by dashed line *A'B'* in Fig. 18, and the over-all speed–torque curve assumes the shape shown as line *A'B'O'*.

In some installations, the compressor suction throttling device will be instrumented to close automatically whenever voltage fails, in order to unload the machine during the transient period. Under these conditions, the speed–torque requirements during deceleration depend upon the speed at which the throttling device closes. In many installations, the throttling device will not move significantly before the compressor has decelerated to the speed at which it can no longer overcome the system pressure and the speed–torque characteristics will be as described in the preceding paragraph. Using this assumption will produce conservative results. During reacceleration, the compressor torque will follow the square relationship no-flow curve until the speed is reached where flow begins. If the guide vanes have closed nearly all the way the time flow is re-established, the resulting speed–torque curve will be similar to that shown by line *O'B'G'* in Fig. 18. Torque at full speed is approximately equal to the torque occurring at the full-speed throttled surge limit corresponding to the existing system discharge pressure.

CONCLUSIONS

DETERMINATION of the torque requirements of centrifugal pumps and compressors during transient conditions requires detailed analyses whenever the machines operate into discharge systems containing some static pressure. Under such conditions, torque varies as the square of speed only in the no-flow range. In the flow range, speed–torque characteristics assume a complex shape which must be determined from the machine and system characteristic curves.

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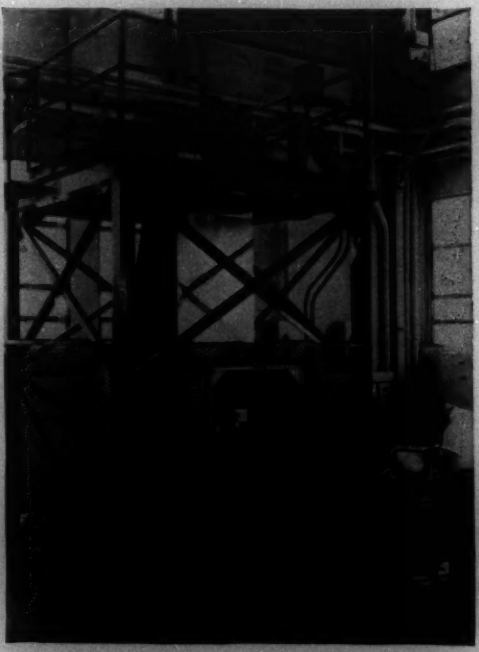
Television Inspection of Tin Plate

A tin strip speeds past the probing eye of a television camera in an experiment which is aimed at the improvement of quality control methods. Conducted at the U. S. Steel Research Center's new electromechanical building at Monroeville, Pa., the experiment is shown being monitored by Carl Willis, technician, who consults a television receiver for an image of the tin's crystal formations.

Through the study of these formations, the Research Center hopes to discover what correlation, if any, exists between the size of the tin crystals and the corrosive resistance of tin plate.

In addition to the television camera (shown in the center of the photograph) and the receiver, the laboratory test stand, which is 14 feet 9 inches tall, is equipped with a stroboscope (next to the camera) which emits a high-density pulsating light. Periodic interruption of the light source stops the speed of the tin plate for the camera—a speed which on a full-scale tinning line may reach 1,200 feet per minute. Passed from the camera, the image is captured in a special storage tube that, in turn, permits the picture to remain on the television screen up to 30 minutes for closer examination, if desired.

A test run based upon this experiment is presently being conducted on tinning lines at the United States Steel Corporation's Tennessee Coal and Iron Division, Birmingham, Ala.



Oil Preservation Systems

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THE most generally adopted systems of oil-preservation, for large high-voltage transformers have been: (1) the oil-conservator system, in which the oil level surface is at constant atmospheric pressure; and (2) the gas-pressure system, in which the upper part of the transformer tank is maintained under a positive gas pressure which is allowed to vary up to approximately 8 pounds per square inch, as the oil volume varies with temperature.

Previously, attention has been drawn to the phenomenon of gas-bubble formation in oil when the gas-pressure system is used. It has been shown that when the oil is in a supersaturated condition, gas bubbles are produced by mechanical vibration and circulating pump action.

Such gas bubbles introduced into the main body of the oil can be a serious hazard by collecting at strategic parts of the winding insulation and reducing dielectric strength of creep paths and flashover distances.

It is the purpose of this present contribution to show that gas-bubbles are also released from supersaturated oil as the direct result of dielectric stress.

Fig. 1 shows a Perspex model carrying ½-inch spheres 2 mm apart, immersed in supersaturated oil. With 10 kv across the spheres, gas-bubbles gradually appear in the stressed zone.

Gas bubbles released in this manner represent an equal hazard, as the release occurs in a stress zone and can produce a local gas pocket and give rise to corona discharge.

Observations have been made on a 103-mva (megavolt-ampere) 230-kv transformer dismantled after approximately 2 years service, where the inner periphery of the insulation on the high-voltage coils in the region of the line terminal showed a "staining" deposit apparently caused by corona action.

Tests with a model simulating a gas pocket in the insulation structure under dielectric stress over a prolonged period, causing corona discharge across the gas-oil surface in the pocket, show the same "staining" as found on the aforementioned transformer.

Chemical analysis showed the "staining" to be of copper sulphide, carried from conductor surfaces and deposited on the paper insulation. Ionized nitrogen combined with oil molecules form amine compounds which dissolve copper sulphide from conductor surface. Diffusion through the oil allows precipitation of sulphide particles to produce the "staining." Such deposits, being of a semiconducting nature, may give rise to trouble after a prolonged service period.

There has not yet been any published evidence of the failure of a transformer that can be directly attributable to these causes, though it has been stated that certain troubles—the causes of which have not been determined for lack of evidence—may have had their beginnings as a result of bubble formation in a gas-pressure system.

Fig. 1. Gas evolution from oil immersed electrodes under electrical stress. Oil is supersaturated.

Corona measurements, in accordance with NEMA (National Electrical Manufacturers Association) publication 107, have been made in the field with transformers with gas-pressure system and show values up to 800 microvolts, after 2 years' service. It was found that after emptying the oil and refilling within 5 to 10 mm of vacuum, the corona value became negligible, thus confirming that the previously measured corona was occurring in pockets of gas. Laboratory measurements on similar transformers also confirm the low corona value resulting from oil-filling under high degree of vacuum, but also show that corona can be expected to appear following application of the gas-pressure cycling.

Corona measurements have also been made on three transformers of similar design, but fitted with a conservator with constant oil surface pressure, after 7 and 8 years of service. These in all instances show freedom from corona.

The general conclusion is that the gas-pressure system carries with it a serious hazard and that the conservator system, or one of its constructional variants, should become eventually the generally accepted method.

Digest of paper 60-81, "Oil Preservation Systems, Factors Affecting Ionization in Large Transformers," recommended by the AIEE Transformers Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960. Published in AIEE *Power Apparatus and Systems*, April 1960, pp. 92-99.

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A Practical Look at Information Theory

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FELLOW AIEE

Concluding article on the nature and basic modes of communication from an engineering point of view.

Part II

IT HAS BEEN shown how information may exist in various states, situations or codes, and that a way has been found to measure the information content of any element of any type of code. It has been found advantageous to convert from one code to another in the interest of time or simplicity, depending on circumstances. Now let us see what happens when the code elements are put together to make a message, and how this message can be transmitted most effectively by applying information theory.

Information can be transmitted by sending codes or analog signals through what may be called a signaling channel. This channel could be a book or motion picture film, but for clarity, an electrical channel can be discussed. Such a channel is characterized by its bandwidth, noise, and distortion. The question to be answered in this case is, "How much information can be sent through this channel in a given time?" Also, how complex must the equipment be to do this and what is the best practical code for our particular purpose—considering complexity, time, bandwidth, and noise?

There is another practical application of information theory. In this case, the question must be broken down into two parts; first, the effect of bandwidth must be considered; secondly, the effect of noise or distortion related to signal strength. It will be found that bandwidth and distortion limit the number of code elements that can be sent regardless of signal strength.

CHANNEL CAPACITY—NYQUIST RATE

IN 1928, one of the theories stated by Nyquist in a paper on telegraph transmission was that in a distortionless channel up to two code elements can be sent per second per cycle of bandwidth for practical systems. This applies to both simple and generally reliable complex codes and is called the Nyquist signaling rate. He assumed that sufficient signal energy could be sent to override noise.[1]

It is relatively easy to visualize why two symbols or digits of a quantized code can be sent per cycle per second if we recall the bandwidth discussion in Part I (June issue). There it was shown that all information could be sent in a voice band of specific maximum frequency if we sampled twice per cycle. Now, two samples produce two symbols. Hence, two symbols can be interchanged for one cycle of top frequency. It follows that if a channel has a capacity of f_{max} cycles per second, it can handle two f_{max} symbols per second.

Here it is very easy to fall into the trap of saying that symbols and information bits are always the same thing and that the channel capacity is two bits per cycle of bandwidth. This holds only for a binary code. For more elaborate codes (ternary, quinary, decimal, etc.) each element can transmit more than one bit. For these the maximum information capacity would be more than two bits per cycle, increasing with code complexity.

If

C = maximum information rate in bits per second (no noise)
B = bandwidth in cycles per second
q = the number of possible quantum steps (selections) an element can assume

Then

$C = 2B$ (number of bits per element)
$C = 2B \log_2 q$ bits per second (no noise)

SIGNALING IN THE PRESENCE OF NOISE

"Well," one may say, "complex codes contain more information per symbol or element." If the number of elements that can be sent per second is limited, a complex code can be used all the time, with many quantum steps, for example, and all the information can be crammed through this channel." Here one runs into the second half of the problem—noise. Noise swamps out the fine steps of complex codes. It was pointed out previously that it is harder to distinguish complex codes. Information theory was applied to this problem a few years ago by Shannon.[2] His studies disclosed what the maximum *information* rate of a channel could be for various ratios of signal-to-noise power. This absolute maximum information rate assumes a perfect coding arrangement, something that has never been obtained because of the complexity of such a system. Shannon's central theorem says that if we are smart enough, a method of coding can be found that would let us send information in a bandwidth B, with signal-to-noise ratio of S/N at the rate

$$C_{max} = B \log_2 \left(1 + \frac{S}{N}\right) \text{ bits per second}$$

Note that this perfect coding rate in the presence of noise is different from our statement for simple quantized PCM (pulse code modulation) code elements without noise. It represents more or less an ideal with which

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This article is based on several informal talks before various AIEE Section meetings.

practical systems such as PCM can be compared. The two statements, however, are only directly comparable when we assume no noise and perfect coding. Theoretically, at least, perfect coding could then give us an infinite rate.

A PRACTICAL CODING SYSTEM

LET US LOOK at a practical coding system, however, and see how far from perfection it is. To do this, two digital pulse codes in the presence of noise are compared. Recognizing that the number of code elements that can be transmitted in a bandwidth are limited to something less than two per cycle of bandwidth, and wanting to cram the most information into each element, we fall back on information theory and see what can be done by converting from one code to another.

For a given signal power, as the number of possible elements in the code decreases, the amount of noise which can be tolerated increases. Conversely, if a more elaborate code is desired, very much less noise can be tolerated.

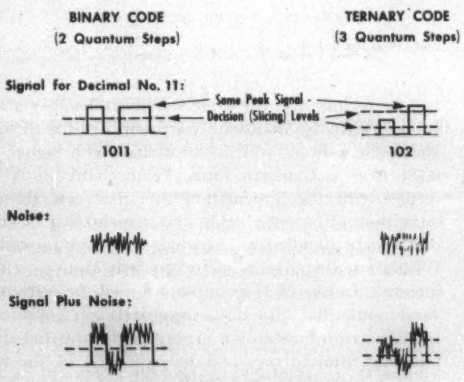

Fig. 5. Signaling in the presence of noise.

The extent to which complex codes can be used in the presence of noise is illustrated in Fig. 5. This compares a binary code and a 3-element or ternary code for the same noise and maximum signal levels.

In the illustration, the equivalent of the decimal number 11 is expressed in both binary and ternary codes, assuming the same peak signal level in both cases. The binary signal jumps from zero to peak, whereas the ternary must, in addition, transmit an intermediate level midway between zero and peak output.

At the receiving end of the signaling channel, the decision must be made as to whether a zero or a one was sent, in the case of the binary; or whether a zero, a one, or a two signal was present for the ternary code. If the level is above a certain point, a decision must be made to put it into a specific category. Below this critical decision level, it is put into another category.

In the upper section of Fig. 5, the critical decision levels are shown by dashed lines. In the absence of noise and distortion, the decisions are easy. With noise, the job becomes more complicated. Let us see what happens when noise is present.

In Fig. 5, immediately below the two codes, are plotted more or less identical levels of noise. For convenience, the approximation is made that the noise peaks never exceed a certain level. To put it another way, it is assumed this is the peak noise that comes so seldom it can be discounted.

Now these identical noise levels are superimposed on the two different codes. The result is shown in the lower part of Fig. 5. In this example, the noise superimposed on the binary code still makes it possible to distinguish zeros from ones. The noise level does not break through the decision level. For the ternary code under the same conditions the noise overrides the decision levels, and makes it impossible to determine without error the particular quantum step transmitted. For any particular peak-signal-to-peak-noise voltage (or current) ratio, therefore, there is a limit to the complexity of the code and hence the information rate for a given bandwidth.

It must be remembered that this peak noise assumption is a little naive since quite frequently the noise encountered is of the "resistance noise" variety, often called "white noise" (to really mix a metaphor) or Gaussian noise. In such cases, any peak value would be encountered if we wait long enough. Nevertheless, if we disregard the infrequent peaks, this philosophy can still be used by defining the maximum bit rate for a PCM (pulse code modulation) code in terms of peak-signal-to-peak-worrisome-noise (voltage or current).

Fig. 6 shows this relationship in the form of the bandwidth requirements for PCM for various signal-to-noise voltage or current ratios (peak-signal-to-peak-worrisome-noise), assuming a constant information rate. That is, it demonstrates how PCM can trade bandwidth for noise. For convenience, assume a reasonably good speech channel is involved in setting our information rate requirements. If all frequencies are desired up to about 4 kc and with very little distortion, we will sample twice per cycle or 8,000 times per second, and use 128 possible quantum levels per sample. Now 128 levels corresponds to 7 bits of information per sample ($\log_2 128 = 7$), so our information rate for this speech is $7 \times 8{,}000 = 56{,}000$ bits per second.

CURVE EXAMINED

IT WOULD BE HELPFUL to check a few points on this Fig. 5 curve. First, if we want to send 56,000 bits with a binary code, we must send 56,000 binary digits per second because one binary digit can only represent one bit. At two elements per cycle of bandwidth (Nyquist again), this means 28 kc of bandwidth are needed to avoid swamping by the noise.

Now, how much noise is troublesome for a binary code? Looking at the left-hand side of Fig. 5, we see that if the peak-to-peak signal voltage as illustrated is just in excess of the peak-to-peak noise voltage, no

errors will be encountered. This corresponds to a limiting signal-to-noise level ratio of one, or zero db. This point can be seen plotted at the extreme left side of the Fig. 6 curve for zero db signal-to-noise ratio and 28 kc of required bandwidth.

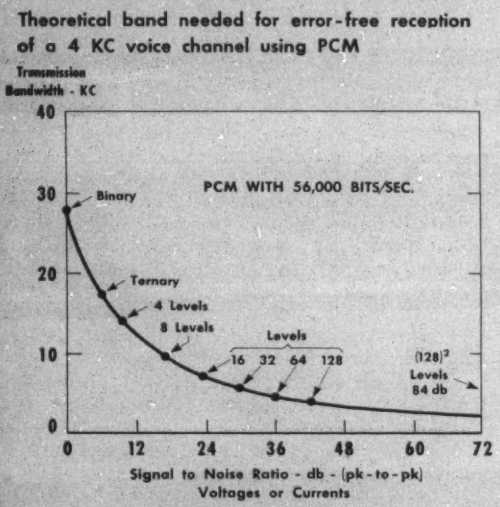

Fig. 6. Bandwidth vs. signal-noise ratio.

Now suppose a 3-level or ternary code was used. By inspection of the right side of Fig. 5, it can be seen that the limiting noise is one-half the peak signal or a 6-db peak-signal-to-peak-noise ratio. Also, a 3-level code contains 1.6 bits ($\log_2 3 = 1.6$). Hence, a bandwidth is needed of $56{,}000/1.6 \times 2$ or slightly in excess of 17.5 kc. This is plotted as the ternary PCM code point in Fig. 6.

Let us now observe the other end of the curve where there may be a surprise. For a 128-level code, we are back at our 128-level quantized sample. Since we sampled 8,000 times per second, we can transmit this 4-kc speech by means of 128-level (128-ary) PCM in 4 kc of bandwidth. By similar procedures as in the previous example, we find we need a signal-to-noise ratio of approximately 42 db.

Now comes the shock. If we use 128 levels in sampling but use more than 128 levels in transmitting (this takes an elaborate coding device), we can send 4-kc speech in less than 4 kc of bandwidth, noise permitting! In theory at least, we could send 4-kc speech in 2-kc bandwidth if we had 84-db signal-to-noise ratio. This is beyond the extreme right end of the curve of Fig. 5. PCM is the only practical coding system that theoretically permits this form of bandwidth compression.[1] Actually, the effort and expense to build coding devices to do this for speech, plus the difficulty of getting such a good signal-to-noise ratio and distortionless channels, makes this entirely impractical with present techniques. The pull of economics has more often pointed toward simple coding and relaxed channel and noise requirements. Bandwidth is in fact getting cheaper, noise and distortion control more expensive.

The mathematical representation of the curve plotted in Fig. 6 is

$$C_{PCM} = 2B \log_2 \left(1 + \frac{S'}{N'}\right) \text{ bits per second}$$

where:

C = information rate
B = bandwidth
S' = peak-to-peak signal (voltage or current)
N' = peak-to-peak noise (voltage or current)

At this point, it would be instructive to learn how PCM compares with the Shannon perfect coding system. Information theory has a few traps into which the unwary can easily fall. It is tempting, for example, to compare the previous statement for PCM directly with Shannon's equation

$$C_{max} = B \log \left(1 + \frac{S}{N}\right)$$

and to assume that the same signals and noises are involved. Actually, Shannon's statement deals with signal and noise powers and assumes that both signal and noise have a Gaussian form. Furthermore, it is concerned with the information rate that gets through, notwithstanding some delay and a sprinkling of errors that can be handled satisfactorily by optimum coding. With Gaussian noise, some errors will always occur at intervals. In our PCM example, we used the convenient (and somewhat practical) approach of considering error-free transmission for a specialized noise that either was peak limited or could be expressed in the form "peak worrisome noise." Also, reference was made to voltage or current ratios rather than power ratios. Thus, the two statements relate to somewhat different conditions and to different types of noise. They are not directly comparable.

If signal-to-noise ratios are expressed as power ratios and white noise is assumed, we can plot another curve somewhat similar to Fig. 6, showing how PCM can trade bandwidth for signal-to-noise power ratio. The derivation is not as straightforward as for our peak voltage comparison, but can be approached from a study of the per cent of the time that white noise exceeds certain specific levels. If certain error rates are assumed which can be tolerated, we can relate the signal power, noise power, and bandwidth requirements for such conditions. Fortunately, several bright people have had the intelligence, time, and enthusiasm to work this out.[2] The relationship is plotted in Fig. 7 for binary and 4-level PCM at two different error rates.

Since Fig. 7 shows what PCM can do in the case of white noise and on the basis of signal-to-noise power

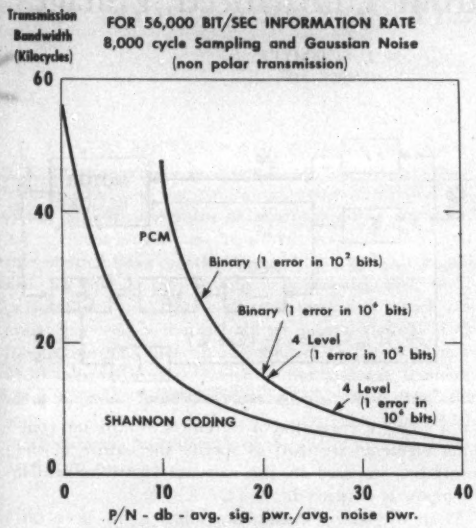

Fig. 7. Comparison of PCM with perfect coding.

ratios, we can compare this performance directly with Shannon's Perfect Coding. This has also been done in Fig. 7. An interesting and somewhat astonishing conclusion results:

> Theoretically, PCM can perform as well as a perfect coding system when operated at about 9-db higher level.[8] Another way of saying this is that PCM theoretically has about 79% of the capacity of a perfect system for the same typical noise levels.

The fact that PCM can theoretically come within 9 db of perfect performance is quite an accomplishment for a readily attainable system compared with the unrealizable perfect coding scheme. Unfortunately, this assumes a distortionless signaling channel, something that is practically unattainable. A more reasonable evaluation is to assume that the undesirable distortions can be controlled by gradually increasing the losses at each end of the band (raised cosine shaping). Under these conditions, the bit rate is reduced about one-half for base-band PCM, compared with perfect coding. It is not so easy to work close to these theoretical limits, however, and practical systems generally operate at a still lower bit rate to allow for some operating margin. This gets us into the 20% range of efficiency.

If PCM base-band operation is changed to pulse coding on frequency-division carrier systems, the information rate in a particular bandwidth may be further reduced. On double sideband AM or FM systems with envelope detection on typical circuits, for example, the efficiency may drop to about 2.5% compared with perfect coding.

PROCEDURES DEPEND ON OBJECTIVES

At this point it may be worth while to summarize a little, and perhaps to philosophize too. It has been shown that an analog signal such as speech can be converted to pulse code and transmitted with varying degrees of efficiency. While most analog signals have the capability of representing great quantities of information measured in bits per second, it is quite rare that they do. Speech is a particularly horrible example in this respect. As far as words are concerned, analog speech waves rarely are more than about 0.1% efficient compared with a perfect code using the same bandwidth.

Actually, voice communication transmits not only the cold facts of information, but, much more often these days, a sense of realism, presence and the personality of the talker. This is really why telephone circuits must be able to exceed the information rate of the spoken words alone, and this is why a coded speech system in encoding this realism factor must generate a multitude of bits. If only words were concerned, a typical 3,000-cycle bandwidth capable of transmitting one speech channel could send the cold information produced by some 20 to 40 speakers, if practical pulse coding and modulation systems were used.

When we communicate, therefore, the procedures used depend on our particular objectives. We must ask whether we are striving for intelligibility of a message or creating an illusion, in the sense of transmitting a personality, a picture or a musical mood. Today we are doing more in all these fields. This in turn calls for a better understanding by all of the communication process.

It can be seen that information theory has several practical applications in giving us a reference and yardstick for comparison of our communication systems. It is a subject into which we can plunge deeply (not without danger of drowning) or just sufficiently for an appreciation of its present value and future possibilities. We hope the dip just taken has been refreshing rather than asphyxiating.

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A-C Servomotor Operation from Unbalanced Voltages

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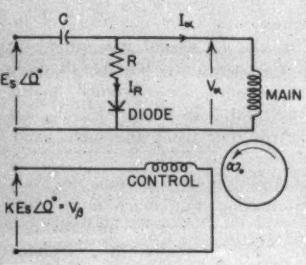
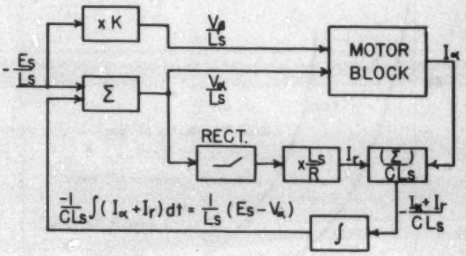


Fig. 1 *(left).* **Phase shift and damping circuit for a servomotor.**

Fig. 2 *(right).* **Analog computer representation of nonlinear impedance in main phase.**



MANY analytical studies directed at the predetermination of output characteristics of a-c servomotors have been predicated on the assumptions of constant source impedance and sinusoidal excitation. Under these assumptions, the method of symmetrical components serves admirably, particularly when steady-state characteristics are desired, and in cases where the duration of the mechanical transients makes the electrical transients insignificant.

In recent years, the use of devices such as chopper modulators, magnetic amplifiers, and gaseous tubes in servomechanism design has caused a-c servomoters to be subjected to new modes of operation. These devices may produce nonsinusoidal waveforms wnich are supplied through constant impedance amplifiers to the servomoter. In other cases, the waveform is nonsinusoidal and the output impedance of the amplifier is nonlinear. With thyratrons or magnetic amplifiers, the output impedance is essentially zero during conduction and approaches open-circuit conditions during the nonconducting period. In addition, the waveform may have either an average value (d-c level), or the direct current may be superimposed on sine-wave excitation to produce some desired dynamic effect.

A considerable volume of literature has appeared concerning magnetic materials, thyratrons, semiconductor devices, etc. Much study has gone into these special devices, but there is a serious lack of information available on the performance of a-c servomotors when operated in conjunction with these nonlinear devices.

Since the usual equivalent circuits and the method of symmetrical components are no longer applicable under nonlinear operating conditions, a more powerful method of attack is necessary. The analog computer, when used to provide a very general representation of the a-c servomotor, provides one method of solving a wide range of problems concerned with the nonlinear and linear steady-state and transient performance of the motor. In this method, the computer is used to determine stator currents and electromagnetic torque of the motor in response to any arbitrary impressed stator voltages, regardless of waveform. Additional computer elements are used to specify the nature of the constraints imposed by the external circuit to which the motor is connected.

As an illustrative example, a solution has been obtained for the problem of a motor operating in conjunction with the diode damping circuit in Fig. 1. The constraints imposed on the V_α main winding motor voltage by the diode, resistor, and capacitor in Fig. 1 are represented by computer elements as shown in block diagram form in Fig. 2. Close correlation between computer studies and laboratory tests has shown the accuracy of this approach to the problem of predicting torques and currents under a wide range of operating conditions.

In the illustration just given, current and torque values for a number of fixed speeds are obtained by manually adjusting two speed coefficients in the "motor block" portion of the computer. Solution of the corresponding problem involving mechanical transients requires an additional computer block which accepts instantaneous electromagnetic torque from the motor block and computes instantaneous speed in terms of the mechanical system constants. Speed is then introduced as an input to the motor block by means of two multiplier units used in place of the previously mentioned manually adjusted speed coefficients.

The analysis of 2-phase servomotors excited through stator impedances which are nonlinear, discontinuous functions of time and current can be accomplished through the use of the analog computer. The simple study presented herein illustrates the basic approach. More complicated studies now can be undertaken with confidence in the computer representation.

Digest of paper 59-1157, "Analysis of A-C Servomotors Operated from Unbalanced Nonsinusoidal Voltage Sources and Nonlinear Discontinuous Source Impedances," recommended by the AIEE Feedback Control Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill., Oct. 11-16, 1959. Published in AIEE *Applications and Industry*, Jan. 1960, pp. 476-81.

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Source and Sink Thermal Resistance Effects

P. E. GRAY

A STATIC ANALYSIS of the thermoelectric generator is necessary in order to specify the electrical loading condition for maximum energy conversion efficiency and to determine the corresponding efficiency. All previous writers on the subject have assumed that the temperatures of the thermal energy source and sink are fixed. This article is concerned with static performance of a thermoelectric generator which operates between a thermal source and a thermal sink having nonzero thermal resistances. This case of nonideal thermal sources, in which the junction temperatures depend upon the rates of heat flow from the source and to the sink, becomes of greater importance as the conversion efficiency of the thermoelectric generator is increased.

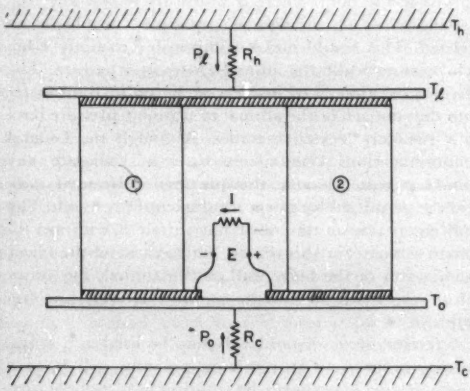

Fig. 1. Device model.

The model which has been studied is shown schematically in Fig. 1. R_h and R_c represent the thermal resistances of the heat source and heat sink, respectively. For convenience in the analysis, these thermal resistances have been normalized with respect to the total parallel thermal resistance of the thermoelectric couple. The normalized resistances are designated by x and y for the heat source and heat sink, respectively, and are assumed to be small compared to unity for the purposes of this analysis.

If x and y are other than zero, the terminal volt–ampere curves of the generator are affected in three ways. First, the open-circuit voltage of the device is reduced because of the flow of conduction heat in the thermal resistances, which results in a smaller temperature drop across the generator. Secondly, the apparent electrical resistance is increased because of the flow of Peltier heat in the thermal resistances. Finally, a nonlinear contribution to the terminal voltage is caused by the temperature drops in the thermal resistances due to Joulean heat flow. These effects are illustrated in Fig. 2, which has been drawn for representative materials parameters and temperatures.

The thermal resistances in the source and sink also affect the maximum efficiency which can be obtained from the generator and influence the value of load current at which the maximum efficiency occurs. Specifically, both the optimum efficiency of the device and the optimum current are reduced due to the presence of thermal resistance. The importance of the corrections which result from accounting for the effect of source and sink thermal resistance is illustrated by the data in Table I.

Table I. Optimum Loading and Efficiency

x	y	Uncorrected Optimum Current, amperes	Corrected Optimum Current, amperes	Uncorrected Optimum Efficiency, per cent	Corrected Optimum Efficiency, per cent
0.03	0.05	24.2	20.9	12.1	10.5
0.10	0.05	24.2	17.6	12.1	9.1

While the modified static theory developed here may not result in major changes in the results of device analysis for low-efficiency devices, the corrections become more and more significant as the device performance is improved through the use of superior thermoelectric materials.

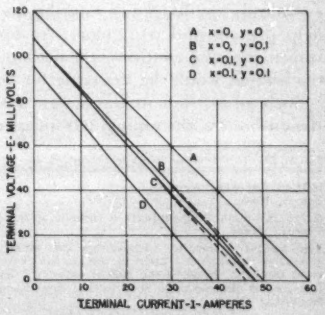

Fig. 2. Terminal volt–ampere curves.

Digest of paper 60-18, "The Effect of Source and Sink Thermal Resistance of Thermoelectric Generator Performance," recommended by the AIEE Solid State Devices Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960. Published in AIEE *Communication and Electronics*, Mar. 1960, pp. 15-19.

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A Telemetering System for Stomach Pressure of Animals

R. W. ALLINGTON

A telemetering system for veterinary research dealing with stomach pressure of ruminant animals is described. The system, consisting of a transmitter, receiver, and recorder, has worked satisfactorily with an animal in a 4-acre enclosure, and greater ranges are anticipated.

CERTAIN ANIMALS, such as cattle and sheep, have a digestive system considerably different from that of human beings. They are able to digest cellulose, whereas human beings cannot. Cellulose is the principal constituent of most plants. Its comparative abundance makes the raising of cattle and sheep economical. After chewing, the animal swallows its food into the first of several stomachs. This first stomach, or rumen, is a fermentation chamber where cellulose is broken down into organic acids and sugars by bacterial action. The product of the rumen can then be utilized by the animal for food. Carbon dioxide and methane are by-products of the fermentation that takes place in the rumen. If the animal cannot remove the gas by eructation, the rumen will swell from the pressure. This produces the condition known as bloat. Once bloated, the animal loses the ability to eructate, and the condition worsens. If not treated, the animal can easily die.

For several reasons, not as much is known about the digestive processes of these ruminant animals as is known of the digestive processes of human beings. It is difficult to study an animal's digestion in such a way so as not to annoy the animal. If the animal is disturbed, its digestive processes may be disturbed. The animal will tend to try to escape from any apparatus that is attached to it, further complicating the problem. The study of typical digestive processes and bloated conditions should lead to information that would better help prevent and treat bloat. An apparatus to record rumen pressure continuously without the awareness of the animal would be desirable for veterinary research.

Such an instrument was designed and constructed by the author for the animal pathology department of the University of Nebraska. Some of the problems encountered in the design are discussed along with the solutions that were adopted. It should be possible to use a somewhat similar instrument to telemeter other information such as temperature, redox potential, or pH.

Essentially full text of a paper awarded the District 6 Student Prize, 1959, and the First Prize in the National Student Papers Competition, held at the AIEE Winter General Meeting, New York, N. Y., Jan. 31-Feb. 5, 1960.

R. W. Allington was formerly a student at the University of Nebraska, Lincoln, Nebr.

The author wishes to acknowledge the assistance received from Mr. J. Schafer in the construction of this device, as well as the advice received from Dr. L. C. Payne of the animal pathology department and Dr. W. C. Robison of the electrical engineering department of the University of Nebraska.

THE TRANSMITTER

SINCE the animal would be aware of any apparatus that might be fastened to it, the recording device has to be at a remote location. In addition to bothering the animal to the point where it would try to tear any connecting wires off, the animal's movement would be restricted. This would make it impossible to study stomach pressure while the animal grazes in a pasture. The obvious solution is to insert a small radio transmitter into the stomach of the animal to transmit pressure data to a remotely located recorder. Although the Federal Communications Commission does not allocate any suitable frequencies for this purpose, unlicensed radiation is permitted for purposes of scientific research. The unlicensed transmitter must not interfere with any licensed service. For this reason, and because of the lower attenuation of the body wall of the animal, the transmitter was made to operate at the relatively low frequency of 90 kc.

A ferrite-cored solenoid coil may be used as a transmitting antenna. The receiving antenna will have a large effective area simply by running it as a single-turn loop atop the fence enclosing the pasture. Coupling between the transmitting antenna and the receiving antenna is that of a very loosely coupled transformer, which is greater than that obtained with the usual straight wire antenna. It is also less sensitive to the position of the animal and transmitter within the pasture, and less prone to pick up outside interference.

The transmitter that is to be inserted into the stomach of the animal must fulfill a number of requirements:

1. The transmitter must be powerful enough to transmit directly to the receiver.
2. The transmitter must be small enough to be inserted orally into the animal's rumen.
3. The transmitter must be large enough so that it will remain in the rumen and not pass into the rest of the digestive system of the animal.
4. Since the measurement of the hydrostatic pressure of the liquid contents of the rumen is not desired, the

transmitter must float with the pressure-sensitive microphone above the liquid level of the rumen. This places a definite limitation upon the transmitter's weight distribution.

5. The ferrite-cored solenoid antenna coil must be aligned within the transmitter so that its axis is vertical. This is necessary to obtain good coupling with the receiving antenna loop, which also has a vertical axis.

6. Since the transmitter does not naturally pass out of the rumen, it must be removed surgically, or by slaughter of the animal. An artificial fistula with a removable plug on the side of the animal is not too practical for the insertion and removal of the transmitter because of pressure leakage around the plug. This makes necessary the longest possible battery life.

7. The pressure-sensitive microphone should have an accuracy of a few per cent, or as close to this as possible. The pressure measurement must be repeatable and stable over the life of the battery.

8. The transmitter must be gas- and water-tight. However, it should not be hard to open to replace the battery.

9. Nonpoisonous and corrosion-resistant materials must be used on all external parts of the transmitter.

10. After the battery of a transmitter becomes exhausted, it may be more desirable to insert more transmitters than to remove surgically the old transmitter. This makes the cost of the transmitter more significant.

Direct amplitude modulation cannot be used to convey the pressure information because of the variation of signal strength that can be expected at the receiver as the animal moves about in the pasture. In the interest of battery life and, to a lesser extent, lower cost, the transmitter circuit must be kept simple. This precludes such things as modulation of subcarriers and other refinements. Frequency modulation of the transmitter seems to be a good solution. The most attractive things about it are the relative independence of receiver upon the signal strength at the receiving antenna, and the simplicity with which the transmitter can be modulated. The modulating technique consists simply of a condenser microphone shunted across the oscillator coil which also serves as the radiating antenna coil. The condenser microphone consists of two metal plates: a fixed plate and a flexible diaphragm that is in contact with the variable pressure source. An increase in pressure forces the flexible diaphragm nearer to the fixed plate, thus increasing the capacitance between them. If the pressure that the microphone is sensing should change, the resultant change in the capacitance of the microphone will alter the resonant frequency of the oscillator coil. Variable-capacitance tuning is used instead of variable-inductance tuning because the latter would interfere with the efficiency of the oscillator coil as a radiator.

Use of a frequency-modulated system places strict requirements upon the frequency stability of the transmitter and the receiver. Any frequency drift will cause an error in the recorded pressure reading. Thermal expansion and contraction of the air within the transmitter can be expected to change the gauge pressure that the microphone senses. Because the flux path of oscillator antenna coil is largely through air, temperature variations in the permeability of its ferrite core are not important. Fortunately, the temperature within an animal's rumen is fairly constant at 40 C.

Since the microphone is placed across the oscillator, or radiating coil, an alternating voltage at the operating frequency will be placed across it. The resultant electrostatic forces upon the movable diaphragm can be expected to cause it to vibrate. This will result in the absorption of power from the system. The resultant loss of battery power is not as great, however, as could be expected with other, more complex, modulating systems.

The transmitter uses a *2N35* n-p-n junction transistor in a modified Hartley oscillator circuit (see Fig. 1). The collector of the transistor, battery, and outer flexible diaphragm of the microphone are at the same radio-frequency potential. This minimizes the capacitive effect of the liquid within the rumen upon the resonant frequency of the oscillator. The autotransformer configuration of the oscillator antenna coil is desirable for two reasons. It makes the frequency of the transmitter less susceptible to variations in the parameters of the transistor. This has a beneficial effect upon the frequency stability of the transmitter. In addition, it increases the power output of the transmitter to the necessary level.

The transmitter battery must have a high ratio of energy to weight and volume. Constancy of battery potential is also necessary for good frequency stability of the transmitter. For this reason, a mercury battery is used for power.

The physical construction of the transmitter is shown in Fig. 2. The 1¼-inch-diameter by 7-inch-long tubular outer case, the end fittings, and interior plastic parts are constructed of methacrylic resin plastic because of its superior physical strength, machinability, and impermeability to water. The weight of the battery in the base of the transmitter causes it to float with the microphone end up.

The microphone diaphragm and fixed plate are constructed of stainless steel. Stainless steel is desirable for another reason besides its corrosion resistance. It is apparently less sensitive to buckling and mechanical hysteresis effects than common shim steel or brass stock.

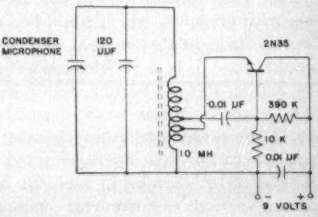

Fig. 1. Schematic diagram of transmitter.

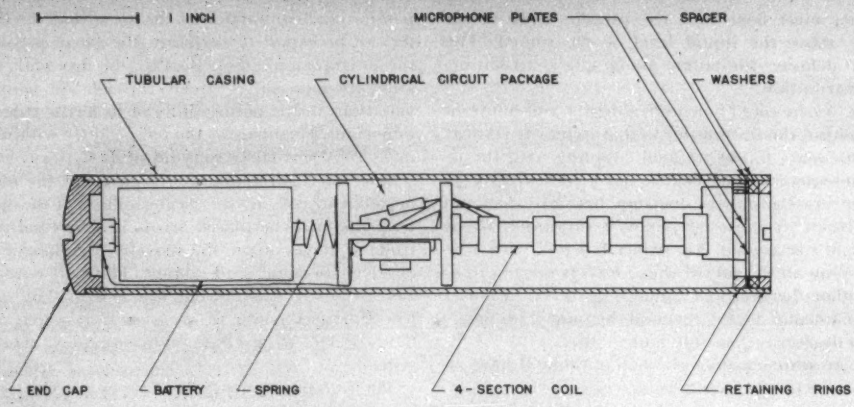

Fig. 2. Semisectional view of transmitter.

This is probably because of its greater toughness and its less pronounced directional grain. The two disk-shaped microphone plates are separated by a polyethylene plastic spacer. The spacer is ring-shaped with a radial depth of $\frac{1}{8}$ inch and a thickness of about 0.0015 inch.

In order to obtain large enough frequency deviation of the transmitter to overcome the effects of transmitter and receiver frequency instability, comparatively large capacitance variations are required of the microphone. The capacitance of the microphone is not necessarily a linear function of applied pressure. The capacitance of the microphone is inversely proportional to the spacing of the plates. This makes the rate of change of capacitance with respect to the change in plate separation greater at smaller plate separations. However, the flexible diaphragm is a nonlinear spring. Its stiffness is greater at greater deflections. With positive pressures upon the flexible diaphragm, these two effects are subtractive. The capacitance change can be made to be substantially linear over a given range of pressure, and at a given pressure sensitivity, by the proper choice of a diaphragm thickness and spacing between the diaphragms. This is limited by a minimum thickness of diaphragm that is necessary for physical ruggedness, repeatability of pressure readings, and lack of mechanical hysteresis in the capacitance vs. pressure curve. At negative pressures upon the diaphragm, the two nonlinear pressure–capacitance functions are additive. This makes the transmitter considerably less sensitive to negative pressures, which could be encountered if there were a drop in the ambient barometric pressure. This could prove to be a problem, but it could be alleviated by sealing the transmitter case under a slight vacuum. The transmitter may be calibrated by operating it in a 40 C constant-temperature chamber in which the air pressure can be varied and measured with a manometer. The effect of changes in ambient barometric pressure during actual experimental operation of the transmitter must be compensated for by using a recording barograph.

The transmitter has a power input of 15 milliwatts. Under this condition, the battery lasts 9 days. A rough idea of the radiated power output of the transmitter can be obtained by the separation of losses in the antenna-oscillator coil. By knowledge of the Q of the coil and the amplitude of the 90-kc voltage across it, the sum of radiated and dissipated power can be calculated. Subtraction of known losses from the total power at the coil gives an estimated value of radiated output power of 2 milliwatts.

The low efficiency is partly caused by the eddy current and hysteresis loss in the lower microphone plate. It is unavoidably situated $\frac{1}{2}$ inch away from the end of the coil and with its plane perpendicular to the axis of the coil.

THE RECEIVER

THE SINGLE-TURN loop antenna surrounding the experimental pasture can be treated as a 2-wire transmission line with the spacing between the wires equal to twice the distance from the loop to the ground. The length of the equivalent transmission line equals the distance along the loop from the receiver to the point opposite the receiver on the other side of the pasture. A closed loop will then constitute a shorted transmission line. If the equivalent line is less than $\frac{1}{8}$ wavelength long, its terminal impedance will be low. An equivalent line with a length of between $\frac{1}{8}$ and $\frac{3}{8}$ wavelength can be made to have a low impedance at the receiver terminals by open circuiting it opposite the receiver for a distance equal to twice the distance from the loop to the ground. At 90 kc, $\frac{1}{8}$ wavelength is 1,360 feet. For square fields of less than 680 feet on a side, the loop should be closed for low terminal impedance.

Being able to keep the impedance of the loop from exhibiting very large variations is a distinct advantage.

It avoids the necessity of making provisions to vary the input impedance of the receiver. In order to match the impedance of the loop antenna, it is necessary only to design the receiver with a low input impedance. When the side of the pasture is less than 1/6 wavelength long, it will be an advantage to use a receiver with a differential-balanced antenna input. This is because interference due to sources external to the pasture will result mostly in a common-mode voltage at antenna terminals.

There are several ways to demodulate the received signal to obtain the pressure information. It is not desirable for the receiver to have a wide enough bandwidth to accept the entire modulated signal because of the high degree of electrical noise that is present in the atmosphere at low frequencies such as 90 kc. The bandwidth of the receiver must be as narrow as possible. This requirement could be accomplished by having a narrow-band receiver tune itself automatically to the received signal. However, there would be the disadvantage that the automatic tuning mechanism could be led astray by an interfering signal. The adopted solution depends on the fact that the pressure information—and, therefore, the instantaneous frequency of the signal—changes at a very low rate. This makes it possible to sweep the receiver continuously across a portion of its tuning range at a predetermined rate. As the signal from the transmitter is tuned across, the receiver will show an output. The recording device is synchronized with time in the longitudinal direction and synchronized with the instantaneous frequency of the receiver in the transverse direction. When the receiver shows an output, the recording paper is marked at the corresponding locus of frequency and time.

The receiver is of the double superheterodyne type with intermediate frequencies of 160 kc and 200 cycles. The reason for the large difference between the two intermediate frequencies is that it is desirable to have both sidebands of the resultant second intermediate frequency present in the output. This condition makes it possible to distinguish the difference on the recorded chart between a continuous signal and a burst of interference. A continuous signal shows on the chart as two transversely displaced marks. These marks center about the corresponding instantaneous frequency of the transmitter.

The total bandwidth of the receiver is about 1,000 cycles at 30 db reduction. The relatively high selectivity of the second i-f stage can result in ringing of the tuned circuits and consequent enhancement of short noise burst type of interference. To prevent this, an automatic amplitude limiter is inserted at the input of the second i-f amplifying stage. The 200-cycle output of this amplifier is fed to a power amplifier, which operates a loudspeaker with a cutoff switch and also sends the 200-cycle output signal to the recorder.

The receiver may be manually tuned or automatically swept by means of a flexible shaft connected to the recorder pen mechanism. There is a 500-to-1 gear reduction in the receiver between the tuning condenser and the drive shaft input to lessen the effect of radial play in the flexible drive shaft.

THE RECORDER

THE RECORDER UNIT contains a drive mechanism which provides sweep times variable from 25 to 100 seconds. The direction of pen travel is automatically reversed at its limits of excursion by an adjustable toggle-action limiting switch and two electrically operated counter-rotating clutches.

The feed of the recording paper is operated by the same drive motor as the pen. Adjustment of the pen-speed control potentiometer gives a paper speed range variable from 2 to 8 inches per hour. A clock-operated set of contacts operates an auxiliary pen which time-marks the paper in the longitudinal direction. The recording is made on a 300-foot-long 6-inch-wide roll of electric-marking Western Union "Teledeltos" type *L-39* paper.

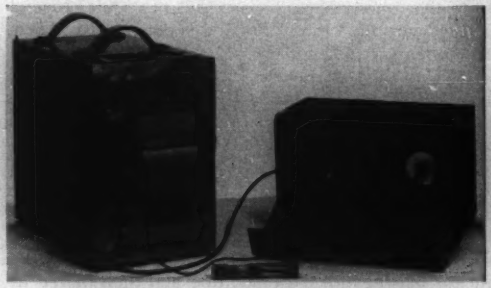

Fig. 3. View of transmitter, receiver, and recorder.

The 200-cycle signal output of the receiver is fed to an untuned amplifier in the recorder. The output of this amplifier is rectified and fed to a simple network which delays its output by 1/10 second. This helps discriminate against noise or interference of a duration less than 1/10 second. The output of the network is fed to a Schmidt trigger, which is direct-coupled to two thyratrons in a full-wave rectifier circuit. The thyratrons operate the recording pen, marking the recording paper when the receiver is tuned to the transmitted signal.

Fig. 3 is a photograph of the recorder, receiver, and transmitter. Depending upon the speed at which the recorder is run, the cost of paper varies between 12 and 50 cents a day. The operational battery cost of the transmitter is about 15 cents a day. The significant expenses in the operation of the system are the calibration, insertion, and removal of the transmitter. Up to the present time, the system has worked with experimental animals in a pasture as large as 300 feet square. During this test, the antenna used was simply the barbed-wire fence surrounding the pasture. Even better results may be expected with an insulated antenna loop placed atop the fence.

Irradiated Magnet-Wire Insulation

J. W. KALLANDER
MEMBER AIEE

MAGNET wire is probably the most basic component of electric equipment. With the advent of nuclear power and the application of electric apparatus in a radiation ambient, it becomes important to determine the capabilities of electrical materials in a radiation ambient as well as the effect of irradiation on the engineering properties of the material. While there are relatively abundant sources of information on the mechanical property changes induced in insulation by high-energy radiation, there is comparatively little information on the induced electrical property changes.

The effects of gamma irradiation on the thermal aging lives and the electric strengths of a wide range of magnet wire insulations have been determined. These experiments were conducted by exposing the insulation samples to the radiation field and then to the thermal and/or voltage fields although it is realized that the effects of exposure to radiation followed by exposure to temperature are not necessarily the same as the effects due to the simultaneous exposure of the insulation to the radiation and thermal fields. Consequently, the information obtained will be of value in designing and evaluating electric equipment which may be either advertently or inadvertently (such as an atomic or nuclear blast) exposed to radiation and then placed in an operational status. In addition, since the practical concept of simultaneous radiation-temperature exposure of insulation is in its infancy, it will be some time before sufficient experimental data and theoretical analyses are available to be of practical use. In the interim period, of course, engineers designing and evaluating electric equipment must use the successive exposure information of the type presented here. Since the successive exposure test is so much simpler than the simultaneous exposure test, it should always be of use as a first approximation or "screening" test. Finally, as considerable information on simultaneous exposure tests becomes available, it may be possible to correlate the results of the two types of tests, thus enabling the successive exposure test to replace, with a reasonable degree of accuracy, the more complicated simultaneous exposure test in some applications.

Magnet-wire specimens of 24 different combinations of insulation and varnish (in several cases, no varnish) were prepared according to AIEE Test Procedure No. 57. For 13 combinations, both the thermal lives and electric strengths following removal from the radiation field were determined, while for 4 combinations the thermal lives only, and for 7 combinations the electric strengths only were determined. Upon removal from the gamma radiation field, some specimens were subjected to thermal life tests as prescribed by AIEE No. 57 while the electric strengths of others were determined shortly after removal from the radiation source.

It is clearly shown that radiation affects the thermal and electrical properties of the different classes of insulation to a widely varying degree wthin the limit of radiation dosage considered. The extent of the radiation damage ranges all the way from very little damage to the polyester combinations even at the highest dosage considered, all the way to total—or almost total—destruction of the tetrafluoroethylene combinations even at the lowest dosage considered. The modified polyester, silicone enamel, glass served silicone, polyvinyl formal, polyvinyl formal-nylon combination, and epoxy combinations all give intermediate results.

It is believed that some of the mechanisms of radiation damage affect the thermal life but not the electric strength; conversely, some mechanisms affect the electric strength but not the thermal life while still others affect both the electric strength and the thermal life but to varying degrees. A comparison of the thermal life and electric strength changes of the different combinations should thus show a correlation but not a functional relationship between the electric strength and thermal life changes of each combination. Therefore, a statistical correlation of the material is being made and will be the subject of a future article.

Experience in thermal aging has indicated that failures, by and large, result from mechanical degradation of the insulating material whether it be film or sheet material in phase or ground. Because of this interrelationship, it is reasonable to expect that in radiation degradation studies, the changes in thermal aging characteristics will to a certain extent correspond to the changes in the mechanical properties of the material. In this respect, a study of the extensive literature now available on the effects of radiation on the physical properties of materials for information which can be compared with the thermal and electrical property changes should be an interesting and useful study. If a correlation between the physical, thermal, and electrical properties of irradiated materials can be found, this will greatly simplify the evaluation of these materials for use in radiation environments.

Digest of paper 60-89, "Post Irradiation Thermal and Electrical Properties of Magnet Wire Insulation," recommended by the AIEE Electrical Insulation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 31-Feb. 5, 1960. Published in AIEE *Power Apparatus and Systems*, April 1960, pp. 42-49.

J. W. Kallander is with the U. S. Naval Research Laboratory, Washington, D. C.

This work was sponsored by the Electric Branch (code 660K) of the Bureau of Ships, U. S. Navy.

INSTITUTE ACTIVITIES

1960 Pacific General Meeting Will Take Place August 9-12 in San Diego

THE 1960 Pacific General Meeting of the AIEE will be held in San Diego, Calif. Technical sessions are scheduled for Tuesday, August 8, through Friday, August 12. Headquarters for the meeting will be in the El Cortez Hotel. The registration desk will be open Monday afternoon and evening preceding the start of the technical sessions on August 9.

Requests for hotel reservations should be directed to: Donald Struck, San Diego Convention and Tourist Bureau, 924 Second Ave., San Diego 1, Calif. Rooms are available in the following hotels:

Downtown Hotels

El Cortez (headquarters)	$8—$25
San Diego	$3—$18
U. S. Grant	$7—$25

Motor Hotels

Mission Valley (5 to 10 minutes by Freeway)	(Summer rates)
Del Webb's Hiwayhouse	$10—$15
Kings Inn	$8—$16
Mission Valley Inn	$8—$18
Rancho Presidio Hotel	$13—$17
Stardust Motor Hotel	$8—$16
Town and Country	$8—$16
Vagabond Motor Hotel	$9—$12

Motor Hotels are located in Mission Valley, a 10-minute drive from downtown by Freeway. Parking is available at all hotels and motels.

Technical Program

The technical sessions will cover the latest developments in many fields of interest to AIEE members. An event of special interest on the technical program will be a meeting of the Aero-Space Transportation Committee, whose technical program is being developed around the theme "Electrical Frontiers of the Space Age." Papers have been solicited on the subject of "Secondary Electric Power for Missile and Space Vehicles," including nuclear power, electrochemical conversion, solar energy conversion, and thermoelectricity. Other subjects will include ionic propulsion, magnetohydrodynamics, radiation problems, support equipment, and reliability. The Pacific General Meeting conference liaison representative for the Aero-Space Transportation Committee is E. F. Kotnik, Convair Division, General Dynamics Corporation, Department 6-140, San Diego 12, Calif.

In addition, 18 technical committees in the six technical Divisions are sponsoring sessions on the following subjects: domestic and commercial applications, transmission and distribution, transformers, computing devices, wire communication systems, telemetry, radio communication systems, chemical industry, substations, radiation effects, solid-state devices, aerospace instrumentation, communication theory, industrial and commercial power systems, radiation technology, petroleum industry, feedback control systems, and nucleonic and radiation instrumentation.

A student program is planned which will include two technical sessions with prizes offered for the best student papers, a students' luncheon, and a meeting of student counselors. Information on the student program may be obtained from A. H. Keith, 3827 Polk Ave., San Diego 5.

Inspection Trips

Inspection trips are planned to:

South Bay Power Plant, San Diego Gas and Electric Company.

John Jay Hopkins Laboratory, General Dynamics Corporation.

Convair Astronautics Division, General Dynamics Corporation.

Sycamore Canyon Test Facility, General Dynamics Corporation.

Naval Electronics Laboratory, U. S. Navy.

University Avenue Exchange, Pacific Telephone & Telegraph Company. Telephone personnel will be on hand to guide AIEE members through the building and to answer any questions about the operations.

Stromberg Carlson Division, General Dynamics Corporation.

A general program of social and recreational events will offer AIEE members

Convair-Astronautics

AN inspection trip to the Convair Astronautics Division of General Dynamics Corporation will include a tour of the computer and electronic laboratory areas where the Atlas intercontinental ballistic missile is designed and developed. Pictured is a huge steam cloud dwarfing the 100-foot steel tower during captive testing of an Atlas missile at Sycamore Canyon, Calif.

Official Photograph, U. S. Navy

PRINCIPAL West Coast research and development center for underwater and surface electronic devices and weapons systems, the U. S. Navy Electronics Laboratory, San Diego, Calif., will be toured during the 1960 Pacific General Meeting. Pictured is a model range of antenna testing facilities.

an opportunity to relax with their old friends and to become better acquainted with their fellow engineers.

A men's luncheon in the Cotillion Room of the El Cortez Hotel on August 9 will have as the principal speaker, J. R. Dempsey, manager of the Convair Astronautics Division, whose subject will be "The Space World of Tomorrow."

In the evening, a dinner and theater party will be featured. Refreshments and dinner will be served at the House of Hospitality, Cafe Del Rey Moro in Balboa Park. After dinner, the players of the Old Globe Theater will present Shakespeare's play, "As You Like It." Buses will leave the El Cortez Hotel at 5:30 p.m.

On August 10, a highlight of the entertainment events will be a luau and harbor cruise. Buses will leave the El Cortez Hotel at 11:30 a.m. and proceed to the Broadway Pier to board special boats for the trip to the Bali Ha'i Restaurant on Shelter Island. A luau will be served in the Hawaiian Village with entertainment provided by a group of authentic Polynesian dancers. After lunch, the guests will return to the boats, complete a tour of San Diego Harbor, and return to the pier at about 6:00 p.m.

On August 11, the Mission Valley Country Club (site of the San Diego Open) will play host to a golf tournament for those interested. A $5 entrance fee will be charged for this event and participation will be limited to the first approximately 50 persons who sign up for the tournament. Tickets for the golf tournament will be sold at the registration desk only. However, you can insure your participation by indicating your desire to play on the advance registration card.

An evening of dancing and entertainment will be offered August 11 at a banquet in the Caribbean Room of the El Cortez Hotel. Entertainment will be provided by "Lois Ray and her Marionette" and the amplified harmonicas of the "Mulcays." The featured act of the evening will be the nationally known singing group, "The Sportsmen." Charlie Parnell's orchestra will complete the evening with dance music. Dress will be semiformal, and festivities will begin at 7:30 p.m.

Dr. Kenneth McFarland, voted nationally as "America's Foremost Public Speaker," will appear through the courtesy of General Motors at the combined luncheon in the Don Room on August 12. Dr. McFarland's varied interests and broad experience will bring a valuable message to everyone.

Prices for each event are as follows: Tuesday, Men's Luncheon—$3.50 per person; Tuesday, Dinner and Theater Party—$6.00 per person; Wednesday, Luau and Harbor Cruise—$6.00 per person; Thursday, Banquet and Dance—$7.50 per person; and Friday, Combined Luncheon—$3.50 per person.

Special events are planned for the ladies. On Tuesday at 12:30 p.m., there will be a luncheon and fashion show in the Don Room of the El Cortez Hotel. The fashion show will be presented by the El Cortez Fashion Center. The tickets for this event will cost $4 per person.

Thursday will feature a bus trip to La Jolla, combined with a luncheon and shopping tour. Buses will leave the El Cortez Hotel at 11:00 a.m., arriving in La Jolla in time for luncheon at noon at the La Valencia Hotel. After a shopping tour of the local shops, buses will return to the hotel at 3:00 p.m. Tickets will be priced at $3.50.

The pool patio at the El Cortez has been reserved for morning and afternoon coffee hours for the ladies. Coffee will be served each morning of the meeting from 9 to 11 a.m., and each afternoon from 3 to 4:30 p.m. Bridge tables and cards will be available for those ladies wishing to play bridge or canasta.

PACIFIC Telephone's University Toll Center will be visited by AIEE conventioneers as a feature of the 1960 Pacific General Meeting activities. The CAMA (Centralized Automatic Message Accounting) equipment that connects San Diegans into the Nationwide Dialing System will be viewed. Touring groups will see the toll and television center, where microwaved television programs, carried by local San Diego Stations, are monitored by telephone technicians to insure quality audio and video transmission.

Busco-Nestor

General Committee

The General Committee for the 1960 Pacific General Meeting consists of the following: J. F. Sinnott, chairman; M. R. Marston, vice-chairman; R. T. Strong, treasurer; G. C. Eggen, secretary; W. A. Davis, chairman—transportation and inspection trips; A. H. Keith, chairman—student activities; G. B. Kenline, chairman—arrangements; R. Kinslow, chairman—golf tournament; L. R. Knerr, chairman—hotel and registration; E. Kotnik, chairman—technical papers; Mrs. M. R. Marston, chairman—ladies' activities; R. K. Walter, chairman—entertainment; H. R. Hughes, chairman—publicity; A. Paul, chairman—finance.

Technical Program

The tentative schedule of technical sessions follows:

Tuesday, August 9

9:00 a.m. Sessions

Aero-Space Transportation

Heat Pumps and Space Heating

CP.* Thermoelectric Heating and Cooling. *R. L. Eichorn*, Whirlpool Laboratories

CP.* Baseboard Heating. *Douglas Quirk*, Hotpoint, Inc.

CP.* New Applications in Heat Pumps. *Donald Slack*, General Electric Company

CP.* Computation and Measurement of Leakage Currents in Floor Heating Grids. *H. P. Gluckman*, Department of Water and Power, Los Angeles, Calif.

CP.* Principles of Electric Heating for Schools, Churches and Commercial Buildings. *S. L. Forsyth*, Montgomery Bros.

Transmission and Distribution

CP.* Abnormal Voltages on Control Circuits of Pole Top Switched Capacitor Banks. *D. C. Keezer, A. E. Henderson*, Pacific Gas & Electric Co.

60-1001. Effect of Metal-Dielectric Junction Phenomena on High-Voltage Breakdown Over Insulators in Vacuum. *M. J. Kofoid*, Boeing Airplane Co.

CP60-1002. The Variability of Alternating-Current Corona. *H. S. Dixon*, Berkeley Laboratory

Transformers

CP.* The Insulation Systems Approach to Oil-Filled Power Transformers. *J. R. Meador*, General Electric Co.

CP.* Auto Transformer and Resistance Methods of Load Tap Changing. *H. L. Prescott*, Westinghouse Electric Corp.

60-1003. Theory & Design of Premagnetized Current Transformer. *T. K. Bose*, Heavy Electricals Ltd.

CP.* A Self-Resetting Pressure Relief Device for Transformers. *M. Aronson*, McGraw-Edison Co.

*Conference papers will not be reprinted by the Institute; however, they may be available at the meeting at the discretion of the author.

AIEE Future Meetings

International Federation of Automatic Control Convention
Moscow, Russia
June 27—July 6, 1960

Pacific General Meeting*
El Cortez Hotel
San Diego, Calif.
August 8-12, 1960

Aero-Space Transportation Conference*
El Cortez Hotel
San Diego, Calif.
August 8-12, 1960

AIEE-AIChE-IRE-ISA-ASME Joint Automatic Control Conference
Kresge Auditorium
Massachusetts Institute of Technology
Cambridge, Mass.
Sept. 6-9, 1960
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—July 5)

AIEE-ASME Engineering Management Conference
Morrison Hotel
Chicago, Ill.
September 14-16, 1960
(Final date for †TP—closed, ‡CP Syn.—July 1, CPMs—July 11)

AIEE-IRE Industrial Electronics Symposium
Manger Hotel
Cleveland, Ohio
September 21-22, 1960
(Final date for †TP—closed, ‡CP Syn.—July 8, CPMs—July 18)

AIEE-ASME National Power Conference
Bellevue-Stratford Hotel
Philadelphia, Pa.
September 21-23, 1960
(Final date for †TP—closed, ‡CP Syn.—July 8, CPMs—July 18)

Petroleum Industry Conference
Skirvin Hotel
Oklahoma City, Okla.
September 25-28, 1960
(Final date for †TP—closed, ‡CP Syn.—July 12, CPMs—July 22)

Fall General Meeting
Morrison Hotel
Chicago, Ill.
October 9-14, 1960
(Final date for †TP—closed, ‡CP Syn.—July 21, CPMs—Aug. 5)

AIEE-IRE-SMPTE National Electronics Conference
Sherman Hotel
Chicago, Ill.
October 10-12, 1960
(Final date for †TP—July 12, ‡CP Syn.—July 27, CPMs—Aug. 5)

Nonlinear Magnetics and Magnetic Amplifier Conference
Bellevue-Stratford Hotel
Philadelphia, Pa.
October 26-28, 1960
(Final date for †TP—July 28, CPMs —July 15)

AIEE-IRE-ISA Electrical Techniques in Medicine and Biology Conference
Sheraton Park Hotel
Washington, D. C.
October 31—November 2, 1960
(Final date for †TP—Aug. 2, ‡CP Syn.—Aug. 17, CPMs—Aug. 26)

Power Industry Computer Application Conference
Chase Hotel
St. Louis, Mo.
November 9-11, 1960
(Final date for †TP—Aug. 11, ‡CP Syn.—Aug. 26, CPMs—Sept. 5)

AIEE-AIP Magnetism and Magnetic Materials Conference
Hotel New Yorker
New York, N. Y.
November 14-17, 1960
(Final date for †TP—Aug. 16, ‡CP Syn.—Aug. 31, CPMs—Sept. 9)

AIEE-NEMA Electrical Insulation Conference
Conrad Hilton Hotel
Chicago, Ill.
December 5-8, 1960
(Final date for †TP—Sept. 6, ‡CP Syn.—Sept. 21, CPMs—Sept. 30)

AIEE-IRE-ACM Eastern Joint Computer Conference
Hotel New Yorker
New York, N. Y.
December 11-14, 1960
(Final date for †TP—Sept. 12, ‡CP Syn.—Sept. 27, CPMs—Oct. 7)

AIEE-IRE-ASQC Reliability & Quality Control Conference
Bellevue-Stratford Hotel
January 9-11, 1961
(Final date for †TP—Oct. 11, ‡CP Syn.—Oct. 25, CPMs—Nov. 4)

Winter General Meeting
Hotel Statler
New York, N. Y.
January 29-February 3, 1961
(Final date for †TP—Oct. 31, ‡CP Syn.—Nov. 10, CPMs—Nov. 25)

AIEE-IRE-U of P International Solid-State Circuits Conference
Philadelphia, Pa.
February 15-17, 1961
(Final date for †TP—Nov. 17, ‡CP Syn.—Dec. 2, CPMs—Dec. 12)

South East District Meeting
Jung Hotel
New Orleans, La.
April 5-7, 1961
(Final date for †TP—Jan. 5, CPMs —Jan. 30)

Materials Handling Conference
Chicago, Ill.
April 11-12, 1961
(Final date for †TP—Jan. 11, ‡CP Syn.—Jan. 26, CPMs—Feb. 6)

Cement Industry Conference
Sheraton-Cadillac Hotel
Detroit, Mich.
April 18-20, 1961
(Final date for †TP—Jan. 18, ‡CP Syn.—Feb. 2, CPMs—Feb. 13)

Great Lakes District Meeting
Hotel Pick-Nicolett
Minneapolis, Minn.
April 19-21, 1961
(Final date for †TP—Jan. 19, CPMs —Feb. 13)

Rural Electrification Conference
Kentucky Hotel
Louisville, Ky.
May 1-2, 1961
(Final date for †TP—Jan. 31, ‡CP Syn.—Feb. 15, CPMs—Feb. 24)

AIEE-IRE-ACM Western Joint Computer Conference
Ambassador Hotel
Los Angeles, Calif.
May 9-11, 1961
(Final date for †TP—Feb. 8, ‡CP Syn.—Feb. 23, CPMs—Mar. 6)

North Eastern District Meeting
Statler Hotel
Hartford, Conn.
May 17-19, 1961
(Final date for †TP—Feb. 16, CPMs —Mar. 13)

Fractional Horsepower Motors Conference
Biltmore Hotel
Dayton, Ohio
May 23, 1961
(Final date for †TP—Feb. 22, ‡CP Syn.—Mar. 9, CPMs—Mar. 20)

Summer General Meeting
Cornell University
Ithaca, N. Y.
June 18-23, 1961
(Final date for †TP—May 20, ‡CP Syn.—May 30, CPMs—Apr. 14)

*Final date for submitting papers—closed

†**TP**—Transactions Paper
‡**CP Syn.**—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

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Computing Device Technology

CP.* Message Composers. *J. F. Donan*, Aeronutronic

CP60-1005. Rotating Raster Character Recognition System. *R. W. Weeks*, International Business Machines Corp.

CP.* Airbourne Digital Computer Reliability. *J. F. Cherney*, North American Aviation, Inc.

60-1004. The Principle of Equivalent Areas. *R. E. Andeen*, Sperry Rand Corp.

60-1006. Amplidyne Circuit Analysis. *G. W. Bills*, North American Aviation, Inc.

2:00 p.m. Sessions

Aero-Space Transportation

Wire Communication Systems

60-998. Two-Wire Operation of *N* Carrier Systems. *R. W. Dean*, Pacific Telephone & Telegraph Co.; *E. M. Karkar*, Lynch Communications Systems, Inc.

CP60-999. Impulse Noise on *N* Carrier. *S. D. Overby*, Pacific Telephone & Telegraph Co.

CP.* Transmission Problems Involved in Using Normal Telephone Facilities at Frequencies up to 400 Kc. *E. E. Combs*, Lynch Carrier Systems, Inc.

CP.* Interconnection Circuits for Carrier Networks. *D. Welling, R. C. Herrick, A. M. Seymour*, Lenkurt Electric Co.

Transmission and Distribution

59-884. An Aviation Hazard Light for Mid-Span Operation on Power Transmission Lines. *H. J. Dana*, Washington State Institute of Technology

60-1000. Some Chemical Treatments to Reduce the Resistance of Ground Connections. *R. J. Clark, B. O. Watkins*, Utah State University

CP.* Computer Application to Determination of Power System Circuit Breaker Duties. *M. J. Lantz*, Bonneville Power Administration

Computing Design Automation

CP.* RW Logic Simulation Program. *H. Adler, H. Jacobs*, Ramo Wooldridge.

CP60-1007. A Computer Program for Preparing Wiring Diagrams. *Mrs. D. B. Kirby, C. W. Rosenthal*, Bell Telephone Labs., Inc.

CP.* Variable Block Logic Diagram Program. *P. Quantz*, Burroughs Corp.

CP.* An Interpretive Simulation Program for Estimating Occupancy and Delay in Traffic-Handling Systems which Are Incompletely Detailed. *D. L. Dietmeyer*, University of Wisconsin; *G. Gordon, J. P. Runyon, B. A. Tague*, Bell Telephone Labs., Inc.

Telemetry

Wednesday, August 10

9:00 a.m. Sessions

Aero-Space Transportation

Radiation Effects Symposium—I

CP.* The Black Science of Nuclear Measurements. *J. D. Simpson*, General Electric Co.

CP.* Techniques of Counting Foils and the Interpretation of Useful Information from the Counts. *R. E. Wood, J. F. Kinze*, General Electric Co.

CP.* Neutron Flux Measurements in Tett Reactor. *C. H. Hogg*, Phillips Petroleum Co.

CP.* Recent Development in Radiation Instrumentation. *H. A. Thomas*, General Atomic

Radio Communication Systems

60-995. Establishment of a 450-Mc Vehicular Radio System in the Los Angeles Basin. *G. Applegarth*, The Pacific Telephone Co.

60-996. Centralized Testing of a VHF Mobile Radio System. *D. L. MacDonald*, Pacific Telephone & Telegraph Co.

CP60-997. A Problem of TV Interference to VHF Maritime Services. *A. C. Cline*, Pacific Telephone Northwest

CP.* Establishing a Unique Microwave System to John Day, Ore. *P. Austin*, Pacific Telephone & Telegraph Co.

Electrochemical Technology

CP.* Operating Record of Sealed Tank Mercury Arc Rectifiers. *L. J. Harris*, Aluminum Co. of America

CP.* Mechanism of Electrode Reactions in Fused Salt Electrolytes. *H. Stern, J. G. Surendranath*, Washington State University

CP.* Some Technical Aspects of Electrical Safety in Aluminum Potlines. *G.B.S. Rickettes*, Kaiser Aluminum & Chemical Corp.

CP.* Liquid Metal Switching. *K. A. Ahmad*, International Business Machines Corp.

Substations

CP60-1008. Phasing Conventions for the Designation of Busses and Conductors in Outdoor Switch-racks. *O. R. Bulkley*, Southern California Edison Co.

CP60-1009. Substation Design Practices Utilizing 115-13.8 Kv Single-Circuit Integral Units. *W. L. Kelly*, General Electric Co.; *P. W. Kiesling*, Public Service Co. of Colorado

CP60-1010. Adaption of Single Feeder Unit Substations to the Wichita Metropolitan Area. *E. J. Karsten*, Kansas Gas & Electric Co.

2:00 p.m. Sessions

Aero-Space Transportation

Radiation Effects Symposium—II

CP* Radiation Environment in Space. *F. S. Johnson*, Lockheed Aircraft Corp.

CP* A Review of Pulse Nuclear Radiation Effects. *J. Maxey*, Space Technology Labs., Inc.

Radio Communication Systems

CP.* Off-the-Air TV Problems in the Northwest. *E. R. Conly*, Bell Telephone Co. of Nevada

CP60-992. Automatic Precipitation and Temperature Reporting Over a VHF Radio System. *E. J. Warchol, M. S. Sachs, H. S. Lorentson*, Bonneville Power Administration

CP60-993. Design of a Dispatch Mobile Radio System Using Multiple Base Stations. *J. H. Gibbs, L. W. Parsons*, Pacific Telephone—Northwest

CP60-994. Proposed Monocycle-Pulse, VHF Radar for Airborne Ice and Snow Measurement. *J. C. Cook*, Southwest Research Institute

Solid-State Devices

CP.* Compound Two-Ports Systematized. *T. R. Nisbet, W. W. Happ*, Lockheed Aircraft Corp.

CP.* Jacobians of Frequency-Selective Networks. *T. R. Nisbet, W. W. Happ*, Lockheed Aircraft Corp.

CP.* Systematic Formulation of the Sequal Flow Graph of a Complex System. *W. W. Happ, J. L. Burroughs*, Lockheed Aircraft Corp.

CP.* A Numerical Routine Suitable for Computer Evaluation of Complex Flow Graphs. *W. W. Happ, J. L. Burroughs*, Lockheed Aircraft Corp.

CP.* Distribution Parameter Networks for Microminiaturization. *P. S. Castrow, W. D. Fuller*, Lockheed Aircraft Corp.

CP.* Circuit Fabrication from Refractory Materials. *W. D. Fuller*, Lockheed Aircraft Corp.

Aero-Space Instrumentation

Substations

CP.* Design and Construction of an All-Aluminum Substation. *O. R. Bulkley, R. S. Melville, N. E. Weber*, Southern California Edison Co.

CP60-1011. Ground Grids for High-Voltage Stations IV—Resistance of Small and Large Substations. *E. T. B. Gross*, Illinois Inst. of Technology; *E. J. Wallman*, General Electric Co.

CP60-1012. Optimum Diameter, Spacing, and Burial Depth of Ground Grid Conductor. *R. F. Stevens*, Bonneville Power Administration

Thursday, August 11

9:00 a.m. Sessions

Aero-Space Transportation

Radiation Technology

CP.* How Radiation from a Nuclear Explosion May Affect Electronic Equipment. *W. R. Langdon*, General Electric Co.

CP60-1015. Neutron and Gamma Irradiation of Some Square Loop and Microwave Ferrites. *R. W. Moss*, Boeing Airplane Co., *C. F. Kooi, M. E. Baldwin*, Lockheed Research Labs.

CP.* Neutron Irradiation of Esaki Diodes. *F. J. Reid, L. W. Aukerman, R. D. Baxter*, Battelle Memorial Institute

CP.* Electron Irradiation of Silicon Solar Cells. *J. C. Fraser*, General Electric Co.

CP.* Proton Damage to Solar Cells. *K. T. Chow, E. A. Lodi*, Lockheed Missile Systems Div.

CP60-991. Radiation Shielding for Space Vehicles. *J. W. Keller, N. M. Schaeffer*, General Dynamics Corp.

Industrial and Commercial Power Systems

CP.* Power Distribution and Associated Problems when Dealing with Taconite Ores. *A. F. Reynolds*, United States Steel Corp.

CP.* Electric Systems for Power and Lighting at the New Los Angeles International Airport. *J. S. Hamel*, Burbank, Calif.

CP.* Electric Load Calculations for Industrial Power Systems by Digital Computer. *C. W. Boice, Jr.*

CP.* Techniques of High-Frequency Distribution within Buildings. *J. N. Robertson*, Los Angeles Dept. of Water and Power

2:00 p.m. Sessions

Aero-Space Transportation

Radiation Effects Round Table

Round Table Discussion led by:

CP.* E. J. Wesley, U. S. Navy Radiological Defense Lab.

CP.* J. W. Lindner, Space Technology Lab., Inc.

Nucleonic and Radiation Instrumentation

Solid-State Devices

CP.* Transistor-Tunnel Diode Combination Produces an *N*-Type Negative Resistance Characteristic. *C. D. Todd*, Hughes Aircraft Corp.

CP.* A Survey of Semiconductor Materials Technology. *J. H. Myer*, Hughes Aircraft Corp.

CP.* Equivalent Circuit Characteristics of the Solar Cell. Lockheed Aircraft Corp.

CP60-1014. The Propogation of Production Spread Error in Transistor Calculations. *T. R. Nisbet*, Lockheed Aircraft Corp.

CP.* High-Temperature Conversion by High-Temperature Semiconductors. *S. W. Kurnick, R. L. Fitzpatrick, J. F. Leavy*, General Atomic

Friday, August 12

9:00 a.m. Sessions

Aero-Space Transportation

Feedback Control Systems

Radiation Effects

CP.* Radiation Induced Currents in Polyethylene. *J. W. Winslow*, U.S. Naval Radiological Lab.

CP.* A Thin Plastic Radiation Dosimeter. *K. K. Harris, W. E. Price*, Lockheed Aircraft Corp.

CP.* Gamma Radiation Induced Conductivity in Solid Insulation. *V. Culler, W. Barney, H. E. Wexford*, Corning Glass Works

60-1013. Calculation of Absorbed Dose. *C. H. Cheek, V. J. Linnenbom*, U.S. Naval Research Lab.

Solid-State Devices

CP.* Thermoelectric Converter Under Constant Heat Flux Operation. *P. S. Castro, W. W. Happ*, Lockheed Aircraft Corp.

CP.* Electrical and Thermal Measurements at High Temperatures. *C. Cutler*, General Atomic

CP.* Direct Conversion Reactor Systems. *R. C. Howard*, General Atomic

CP.* Experimental Observations in Cesium Cells. *H. L. Garvin*, General Atomic

CP.* Analysis of Thermonic and Plasma Heat-to-Electricity Converters. *W. B. Teutsch*, General Atomic

Nucleonic and Radiation Instrumentation

SUPPORT THE NEW UNITED ENGINEERING CENTER

PARTICIPATING in the AIEE North Eastern District Meeting on May 2-4 were: (*left to right*) R. H. Taylor, general chairman; E. G. Twohey, president of the Narragansett Electric Company, who was the keynote speaker at the welcoming luncheon; AIEE President J. H. Foote; H. A. Van Dine, Jr., Vermont Subsection chairman; and J. K. Andrews, Providence Section chairman.

Electricity in the 1960's Viewed at North Eastern District Meeting

PROVIDENCE, R. I., was the locale of the AIEE North Eastern District Meeting, held May 2-4 at the Sheraton-Biltmore Hotel. About 360 members and guests attended the 3-day meeting, the theme of which was "Electricity—Key to the Sixties."

A broad technical program included approximately 60 papers, presented at 15 sessions. Among the subjects covered were space heating, communications, electronics, computing devices, transmission and distribution, rotating machinery, and relays.

Inspection trips were made to the Brown and Sharpe Manufacturing Company, the Kennecott Wire & Cable Division of the Okonite Company, the Metals and Controls Corporation, and the U. S. Navy's Atlantic Fleet Destroyer Force at Newport.

Welcoming Luncheon

At the welcoming luncheon held on the opening day of the meeting, General Chairman R. H. Taylor presided. After presenting District and Section officers, he introduced J. K. Andrews, chairman of the Providence Section, who spoke briefly on the prospects of substantial growth in the electrical field in the next decade.

AIEE President J. H. Foote described the benefits as well as the phenomenal growth, both in attendance and number, of the Special Technical Conferences sponsored by the AIEE, either solely or jointly with other societies.

Mayor Walter Reynolds pointed out the expansion and diversification of industry in Rhode Island, as did A. H. Schmidt, director of the Rhode Island Development Corporation, who represented Governor Christopher Del Sesto at the meeting.

The major address was presented by E. G. Twohey, president of the Narragansett Electric Company. He predicted a tremendous expansion of power output during the 1960's. Trends in generation and distribution included further increases in sizes of generating units, with a significant number of 500- and 600-kw units. Reliability is expected to increase and costs to decrease. The use of nuclear energy for generation of electric power will increase, particularly in areas such as New England where the cost of transporting fuels is high. He also predicted an increase in transmission and distribution voltages, with 12.5 kv becoming a more and more common voltage for distribution lines. On the consumers' end, the forecast was for a load growth of 120% in the coming decade, with a large expansion in the fields of electric heating and air conditioning. In addition, he stated there is a definite possibility that electric automobiles might become economically feasible on a large scale.

Technical Sessions

In a session devoted to the rapidly expanding field of electric space heating, three interesting papers were presented. In pointing out the many advantages of electric heating, C. M. Greer of Dittman and Greer, Inc., stated that currently in this country about 175,000 motel rooms, more than 600,000 homes, 350 schools, and 80 or more churches are heated by resistance-type electric equipment. J. W. Megley, Boston Edison Company, dis-

cussed the various factors involved in the application of heat pumps to industrial premises. Also included in this session was a description of industrial and commercial space heating with radiant heat presented by J. Gialanella, of the Quartz Products Company.

One of the outstanding papers presented at a session on transformers was by J. H. Kuisti and F. D. Martzloff, both of the General Electric Company. It describes an arc contact testing device which determines the arc erosion properties of a material quickly and accurately.

A session on communications covered such subjects as chemical control of brush growth, particularly in the vicinity of telephone lines; engineering maintenance in telephone transmission; residential underground telephone facilities; and room-to-room dialing in a large multistory hotel. The latter paper, by H. N. Thornton and P. A. Lund, New England Telephone & Telegraph Company, described the approach and problems involved in replacing the manual communication system of Providence's Sheraton-Biltmore Hotel with a dial private branch exchange incorporating room-to-room dialing.

Award Presented

CHIEF of the Special Defense Projects Branch of the Mobile District of the Army Engineers, (left) J. J. Danaher, Jr. (AM '46, M '50) is pictured receiving the highest civilian award of the Corps of Engineers, the Meritorious Civilian Service Award. The presentation was made by (right) Maj. Gen. F. M. Albrecht, head of the Army Engineers in the southeastern United States, on May 17 at the Mobile District Office. Mr. Danaher was cited for his outstanding engineering contributions in supervising and co-ordinating the design and construction of missile launching and tracking facilities.

"Super Railroads" Is Featured Topic at 3rd AIEE-ASME Railroad Conference

AN attendance of 282 was recorded for the 3rd Annual AIEE-ASME Railroad Conference, held April 20-21 at the Penn-Sheraton Hotel in Pittsburgh, Pa.

J. W. Barriger, president, Pittsburgh & Lake Erie Railroad, was the luncheon speaker April 20 on the topic, "Super Power for Super Railroads."

Mr. Barriger said that the "super railroads," which must be created if privately owned railroads are to survive, will require 10,000- to 15,000-hp locomotives or ones of even higher capacity to capitalize their inherent capabilities. He expressed the opinion that if Congress will permit privately owned railroads to have a bright future, electrification will play the same great role in it between 1965-80 as the diesel locomotive did in 1945-1960.

Electrical engineering progress has removed many obstacles to railway electrification, Mr. Barriger stated, through the development of the ignitron rectifier, the 25,000-volt trolley system using 60-cycle commercial frequency, and the d-c traction motor.

The former $50,000-per-mile track cost for overhead trolley has come down to around $20,000 per mile or less, notwithstanding the higher unit cost of component materials, he explained. Present diesel-electric locomotives can be converted to all-electric locomotives and produce almost twice as much gross ton miles per train hour.

Mr. Barriger asserted that the difference in the cost of electric power generated on the locomotive—compared with that made in a large stationary plant, a 50% saving—when related to the annual power requirements of super railroads, will be found to represent an amount sufficient to pay the interest, depreciation, and maintenance of the distributing systems for maximum-density railroads, and yet leave a balance sufficient to represent an adequate return on the investment required to build these distribution systems.

French Railroads Described

"French Technical Advances in the Field of Railroad Electrification were described in a paper illustrated with color slides (AIEE TP 60-602) by M. F. Nouvion, director of electrical research of the French National Railroads. Rapidly extending its electrification since 1945, this railroad system now has 4,100 route miles electrified of which 1,100 miles utilize the new 25-kv single-phase 50-cycle commercial frequency power supply.

Describing "Automation in Railroading" (AIEE CP-59-632), the Milwaukee Railroad's engineering-trained V. E. McCoy, chief purchasing officer, traced history from early automation such as the air brake to present techniques such as centralized traffic control and electronic accounting machines. Mr. McCoy stressed that the primary aim of railroad automation is threefold: (1) better service to customers, (2) more effective direction of sales and service effort, and (3) better cost control. Labor saving is considered secondary to these.

"Locomotive Repair Costs and their Economic Meaning to Railroads of the United States" (AIEE CP 60-599) was the subject of a controversial but thought-provoking paper by H. F. Brown of Gibbs and Hill, Inc., New York, and former electrical engineer of the New Haven Railroad. Defining "economic" vs. "service" life, Mr. Brown stressed the monetary advantages of retiring old equipment at the end of its "economic" life and pointed out the costs of repairs to the diesel motive power of the nation's railroads.

Efficiency Gains

ASME papers on "The Slippery Spot Concept of Adhesion (ASME 60-RR-2), presented by J. C. Aydelott, locomotive and car equipment department, General Electric Company, Erie, Pa.; "Study of Defects that Originate and Develop in the Treads of Railroad Wheels During Service" (ASME 60-RR-1), presented by J. M. Wandrisco and F. J. Dewez, Jr., U. S. Steel Research Center, Monroeville, Pa.; and "Understanding Wheel-Rail Adhesion" (ASME 60-RR-3), presented by G. M. Cabble, Jr., Westinghouse Air Brake Company, Wilmerding, Pa., all pointed to actual and potential railroad operating savings and efficiency gains from engineering experience in this field.

An overseas contribution was an ASME paper on "Forces Between Wheel and Rail" (ASME 60-RR-6) by Per Erik Olson and Stig Johnsson of the Swedish State Railroads. This paper dealt with a new method of measuring continuously the lateral forces between railroad locomotives and car wheels and the rails over long distances.

In "Spectrographic Analysis of Diesel Engine Lubricating Oils by the Rotating Platform Method" (ASME Paper 60-RR-5), J. C. Smith of General Electric's locomotive and car equipment department described the most promising of a number of methods for analyzing wear products in diesel-engine lubricating oils.

"Automated Testing of Railway Freight Brake Control Valves" (ASME Paper 60-RR-4), by P. W. Brath and E. T. Skantar of Westinghouse Air Brake Company, described the design and construction of a prototype automated machine for the periodic required testing of freight car air brake control components. Design objectives are to provide superior testing methods, to allow use of unskilled personnel as operators, and to reduce total testing costs.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grade, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N.Y.

AMONG those who were present at the Pulp and Paper Conference in April were: *(left to right)* F. W. Fischer, district manager, Whiting Corporation, who presented a paper on crane and hoist systems; C. H. Hudson, Jr., General Electric Company, outgoing chairman of the AIEE Pulp and Paper Industry Subcommittee; and W. R. B. Nickelson, University of Florida, who served on the General Conference Committee of the Subcommittee.

Florida University Is Host to Annual Pulp and Paper Conference

THE 6th Annual Conference on Electrical Engineering as applied to the Pulp and Paper Industry was held April 21-22 in the auditorium of the Dan McCarty Hall on the University of Florida campus. This conference was attended by 160 ranking electrical engineers from the mills and allied industries.

A program of technical papers and timely addresses directed at the improvement of technical operations in pulp and paper mills highlighted the 2-day conference. Inspection trips were made to the nearby paper mills and the University of Florida's continuous digester.

J. M. Yarbrough, Mead Corporation, Chillicothe, Ohio, was elected chairman of the Pulp and Paper Industry Subcommittee of the General Industry Applications Committee of the AIEE. He replaces C. H. Hudson of the General Electric Company in Atlanta, Ga. Other officers elected during the conference were: C. L. Eletson, Hopper Paper Company, Taylorsville, Ill., as vice-chairman, and J. S. Kirkland, Rome, Ga., as secretary.

Conferees Welcomed

Registration and special committee meetings of the AIEE subcommittee took place in Gainesville, Fla., prior to the first session of the conference.

Mr. Hudson opened the conference and introduced Robert Mautz, dean of academic affairs at the University of Florida, who welcomed those attending the conference to the university campus. Mr. Mautz pointed out the university's dedication to the advancement of knowledge through research and partnership with applied industry for the advancement of scientific development, and explained that this represents "applied American ingenuity."

J. J. Berry, chairman of the Jacksonville Section, AIEE, presided at the morning session on April 21.

Papers delivered during the morning session were: "Surge Protection in Paper Mills," by H. B. Greear, General Electric Co.; and "A Pulse-Digital Regulating System for Paper Machine Drives," by R. P. Derrick and C. L. Ivey, Westinghouse Electric Corp.

Mr. Greear discussed the hazards of lightning and voltage surges to electric systems and presented the methods used to avoid many problems created as a result of lightning and overvoltage.

Mr. Derrick and Mr. Ivey presented a new concept in paper machine drives, in the nature of a digital speed regulating system called the Pulsetter.

This digital computer speed regulating system for sectional paper machine drives was later compared, in a rebuttal, to the analog computing system by K. P. Grenfell of General Electric, Schenectady, N.Y., and by Bob Ferrell of Reliance Electric Company, Cleveland, Ohio. These gentlemen stated, in separate rebuttals, that the analog system, as used by their companies, was capable of the same operations as had been pointed out in the presentation of the new digital computer system.

E. W. O'Brien, managing director of Southern Power and Industry, Atlanta, Ga., was guest speaker at the Thursday luncheon. Mr. O'Brien explained that he had directed a survey at 1,200 successful engineers less than 5 years out of college. The results of this survey revealed that human factors were more important than technical factors to success in the engineering field. From this, he concluded that more emphasis should be placed on the human factor and that young engineers should avoid becoming "nose to the grindstone" engineers.

The Thursday afternoon session was presided over by E. H. Overby, Union Bag-Camp Paper Company, Savannah, Ga.

The panel discussion on low-voltage a-c motor insulation prompted a discussion between a panel of experts representing electrical manufacturers and the audience. The chairman for this panel was E. K. Murphy, Rayonier, Inc., Jessup, Ga.

Panel Discussion

This panel discussion resulted in agreement that the new encapsulated a-c motor has an accepted position in industry. Also pointed out was the fact that the encapsulation of a-c motors will add to the temperature rise, and that there is no common standard designed for testing insulation on small motors of the encapsulated design.

A social hour was highlighted by an account of the "Nostalgic Past" by Rev. Hubert White of Atlanta, Ga.

During the second day of the conference, papers were presented by J. R. Stevens, Champion Paper Company; R. D. Clarke, Brown Instrument Company; and W. H. Buford, Container Board and Kraft Paper Division of Continental Can.

Mr. Stevens stated that longer trouble-free periods and better quality paper will result from the improvement of environmental atmospheric conditions by introduction of air conditioning.

Mr. Clarke emphasized the advantage of newly transistorized testing and evaluating instruments which may be applied in paper industry process control. He also pointed out that an expansion will take place in the paper industry during the next few years which will provide many areas for new concepts in testing, data handling, and computation.

Mr. Buford stressed the importance of the selection and storage of critical parts and replacements for a paper mill electric system. Mr. Buford stated that a good set of records giving the history of equipment involved should be kept.

This conference was jointly sponsored by the Pulp and Paper Subcommittee and the Jacksonville, Fla., Section of the AIEE and the Engineering and Industrial Experiment Station of the College of Engineering at the university.

S. A. Bobe of Westinghouse Electric Corporation, Atlanta, Ga., served as chairman of the General Conference Committee. Committeemen were: L. E. Schoonmaker and W. R. D. Nickelson, University of Florida; C. H. Hudson, General Electric Company, Atlanta; R. P. Posey, Westinghouse, Jacksonville; and J. A. Womack, Owens Illinois Glass Company, Jacksonville.

Fred Tambling Studio

AIEE members and guests were entertained by the Akron Chapter Chorus of the SPEBSQSA at the banquet of the Rubber and Plastics Technical Conference in Akron. The banquet was attended by 159 persons.

239 Engineers Attend Rubber and Plastics Conference

A total of 239 engineers were registered at the 12th Annual Technical Conference on Electrical Engineering Problems in the Rubber and Plastics Industries, held April 25-26 in Akron, Ohio.

The banquet featured a message from AIEE President J. H. Foote and a program of informal entertainment.

Inspection trips through the Firestone and Goodyear Tire & Rubber Companies were available at various periods during the 2-day conference.

The technical program consisted of 10 papers and 13 prepared discussions which included the subjects of computers, instrumentation, and rotating machinery.

Because of the increasing popularity of spring conferences, advanced reservations have been made with the Sheraton Hotel in Akron, Ohio, for future technical conferences on the following dates: 13th Annual Conference, April 10-11, 1961; 14th Annual Conference, April 9-10, 1962; and 15th Annual Conference, April 22-23, 1963.

Solid-State Circuits Conference Papers Invited

The 8th Annual International Solid-State Circuits Conference will be held February 15-17, 1961, on the campus of the University of Pennsylvania and the Sheraton Hotel, Philadelphia, Pa.

The conference, sponsored jointly by the AIEE, the Institute of Radio Engineers, and the University of Pennsylvania, will feature papers dealing with circuit properties, circuit philosophy, and design techniques related to solid-state devices in the following general areas:

1. Solid-state memory, storage, and logic elements—such as twistors, thin-film memories and associated circuits, photoelectronic circuitry, etc.
2. Solid-state microwave amplifying mechanisms, such as parametric amplifiers and masers.
3. Solid-state devices performing an integrated circuit function.
4. Cryogenic digital and linear applications.
5. Novel types of solid-state devices—in unique modes of operation—such as those utilizing the Hall effect, high-temperature circuit elements, and solid-state filters and delay lines.
6. Advanced circuitry—with emphasis on significant developments in the art—to the exclusion of data on equipment design.

Papers representing original contributions in these and related fields are invited.

Abstracts—highlighting the nature of the contribution, its significance in the art, and theoretical and experimental results—300 to 500 words in length, which can be accompanied by key illustrations, plus 50-word summaries for advance program mailings, should be submitted in double-spaced typewritten form (and in triplicate) on or before October 14, 1960, to the program chairman: J. J. Suran, Building 3, Room 115, General Electric Company, Electronics Park, Syracuse, N.Y.

Abstracts and summaries should be accompanied by author's name, company affiliation and position title, business and home address, telephone contact, and brief biographical sketch.

Members of the 1961 conference committee include: T. R. Finch and F. H. Blecher, chairman and secretary, respectively, both of Bell Telephone Laboratories, Murray Hill, N. J., and for public relations, Lewis Winner, 152 W. 42 St., New York 36, N. Y.

Joint Committee To Sponsor Medicine and Biology Conference

Plans are now being made for the 13th Annual Conference on Electrical Techniques in Medicine and Biology, which will be held in Washington, D. C., October 31–November 2, 1960, at the Sheraton-Park Hotel.

As in the past, the meeting will be sponsored by the Joint Executive Committee in Medicine and Biology representing the AIEE, the Institute of Radio Engineers, and the Instrument Society of America.

The theme of the conference will be the application of electronic techniques to analytical instrumentation.

Scheduled for discussion are the exploration and application of new electrical and physical techniques for quantification of specific materials, determining molecular structure or providing recognizable characterization of materials of biological interest. Typical subject areas here are:

1. Polarography and specific electrodes; perm-selective membrane methods.
2. Electrical generation of titrant coulometric methods.
3. Nuclear and electron magnetic resonance analysis procedures.
4. Dielectric dispersion and high-frequency titration.
5. Mass spectrometry.
6. Microwave spectroscopy.

Conference Papers Open for Discussion

Conference papers listed below have been accepted by AIEE *Transactions* and are now open for written discussion until July 27. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, AIEE, 33 W. 39th St., New York 18, N. Y., on or before July 27.

59-901 **Fatigue Characteristics of EC and 5005 Alloy Aluminum Wire.** *C. E. Burley*

59-1133 **Phase-Isolated LTC Transformers.** *F. P. Kaspar, J. S. Holtzinger, G. A. Wilson*

60-72 **Design of Chute-des-Passes 345-Kv Transmission Line.** *H. B. White*

60-88 **Study of Thermal Deterioration of Enamelled Wires by Mass-Spectrometer Method.** *Y. Saito, T. Hino*

60-238 **Sound-Barrier Walls for Transformers.** AIEE Committee Report

60-255 **Digital Calculations of Single-Phase-to-Ground Faults.** *H. E. Brown, C. E. Person*

60-493 **Graduate Education in Electrical Engineering in the United States—1959.** *E. C. Easton, T. L. Martin, Jr., J. H. Mulligan, Jr.*

Preprints may be purchased at 50¢ each to members, $1.00 to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 W. 39th St., New York 18, N. Y.

ATTENDING the initial meeting of the Channel Counties Subsection of the Los Angeles Section were: (left to right) M. M. Rypins, secretary-treasurer of the Subsection; Robert Milmoe, vice-chairman, Los Angeles Section; E. L. Peterson, chairman of the Subsection; Dr. R. W. Sorensen, guest speaker; Mark Eldredge, who introduced the speaker; and L. L. Grandi, secretary-treasurer of the Los Angeles Section.

Dr. Sorensen's Address Highlights Meeting of Channel Counties Subsection

AN inaugural address by R. W. Sorensen (HM '54), professor emeritus of electrical engineering, California Institute of Technology, was the feature of the first meeting of the newly organized Channel Counties Subsection of the Los Angeles Section, held April 27, in Santa Barbara.

Dr. Sorensen has served as a consultant to the Indian government in helping to establish an engineering college at Kampur and also as an advisor to the National Academy of Japan. He is a past president of the AIEE (1940). His inaugural speech was entitled, "Was King David an Engineer?"

E. L. Peterson, chairman of the Subsection, presided at the meeting. Prominent among the guests who attended the meeting were: Mark Eldredge of Santa Barbara; and Fred Milmoe and L. L. Grandi, chairman and secretary-treasurer, respectively, of the Los Angeles Section.

Institute's History

The history of the AIEE from its founding up to the present and the relation of the engineering profession to the standards of living and world affairs, as well as the present trends in engineering education, were reviewed by Dr. Sorensen, whose 60 years of engineering practice encompassed the 25th, 50th, and 75th anniversaries of the Institute.

Progress in this country was attributed not so much to the development of natural resources but to the development of people in a "nation under God." The idea of overcoming muscles with scientific skill was exemplified by the story of "David and Goliath." The question was raised as to whether or not the testing of the sling and the selection of five smooth stones were not engineering decisions, and the speaker suggested that the story should be a familiar one to all engineers.

From the story of the founding of the Institute and the first paper by E. J. Huston, which dealt with "The Edison Effect," Dr. Sorensen treated the progress of the industry by decades. In the first decade, papers dealt with the hardware of illumination, Institute politics, instrumentation, the possibility of batteries, and even the production of electricity by solar activity. The second decade introduced a-c and the battle between a-c and d-c. Between the early 90's and the 25th Anniversary in 1909, the controversy of a-c vs. d-c gave place to a controversy between the quarter-phase and three-phase and other combinations, most of which were settled by the famous Scott connection.

In the early days, the Institute had always been active in education, and C. F. Scott was influential in the founding of the Engineering Societies Building as well as the establishment of Student Branches in the various colleges.

In connection with the 25th Anniversary, Dr. Sorensen referred to a dinner reported in *Electrical World*, March 11, 1909, which was held at the Hotel Astor. Silver bowls were centered in the middle of each table containing miniature storage batteries which lit three miniature lamps with tungsten filaments to keep the guests away from flickering candles. Some of those attending the dinner with whom the speaker was personally acquainted were Elihu Thomson, Alexander Graham Bell, A. E. Kennelly, C. P. Steinmetz, C. F. Scott, and Bion J. Arnold. Dr. Kennelly produced the impedance equation and M. I. Pupin produced loading coils and repeater stations. Dr. Steinmetz brought forth the knowledge of the magnetic circuit. Thus, the electrical industry was on its way to becoming a profession comprising research, development, design, manufacture, construction, operation, and special education. As new phenomena were made evident, it was necessary to develop with mathematical symbols and equations a technical language descriptive beyond the range of spoken words.

In regard to the 50th Anniversary, Dr. Sorensen mentioned the contributors who recorded progress in the gold-covered issue of *Electrical Engineering*. In 1912, C. F. Scott did much to revive the Society for the Promotion of Engineering Education, now the American Society for Engineering Education (ASEE), which is promoting a high standard of engineering education. Attention was drawn to the fact that five of the nine authors in the 50th Anniversary issue were college professors, and others were men whose chief interest was research aimed at product improvement. This balance of authors was contrasted with the 1959 75th Anniversary issue, where only one of the 23 authors was a college professor, and only two were members of the ASEE.

Attention was drawn to the work done on professional conduct and registration of engineers by such organizations as the ASEE, the Engineers' Council for Professional Development (ECPD), and the National Society of Professional Engineers, all three of which receive active co-operation from the AIEE. Copies of "The Institute and Its Operations," published in three parts in volume 78 of *Electrical Engineering* for 1959, as well as the "Faith of an Engineer," issued by the ECPD, were distributed, and the speaker recommended that the members of the Subsection take an enthusiastic interest in the activities of all of the previously mentioned organizations.

Trends in Education

In conclusion, Dr. Sorensen commented on recent trends in engineering education and the two dilemmas which confront the industry today. These are the lack of providing the nation with a sufficient number of engineers to hold its established leadership in world affairs and the fact that the general public has been led by improper publicity to accredit the field of science for major achievements of engineering as well as scientific progress. The press and popular opinion all too often overlook the fact that engineers, rather than scientists, design, produce, and direct the operation of the hardware of communication, transportation, and a thousand other applications for the service of mankind. The acclaim being given to science is diverting high school students to the science options.

Reference was made to a recent paper by Dr. F. C. Lindvall, "The Vanishing Engineer," which stated, "It follows then that the engineer shall have an education similar to the scientist in fundamentals, methods, and extent; but distinct and different in objective and motivation." At the end of the paper, the author said, "He is a new kind of engineer. He has not been vanishing. He is changing."

Engineering salaries were reported at a high level, and the Channel Counties Subsection was told of its good opportunity to guide pre-college and local college students. The members were advised that an AIEE Section can become a community welfare instrument of great importance if its members are active in community affairs.

Officers of the first meeting of the new Subsection were as follows: E. L. Peterson, chairman; M. M. Rypins, secretary-treas-

Newly Elected Officers

NAMED to hold office in the Philadelphia Section, AIEE, for the 1960-61 session are: (*left to right*) R. L. Halberstadt, Bell Telephone Company, as chairman; W. O. Mascaro, Atlantic Refining Company, as vice-chairman; T. H. Story, Radio Corporation of America, as secretary; and R. T. Ferris, Philadelphia Electric Company, as treasurer. The officers were elected at a meeting held May 9 in the local Engineers Club.

urer. The meeting covered the reading and adoption of Bylaws and the appointment of a nominating committee. W. S. Knapp, as chairman, and David Zopf, Lane Hart, Eric Porter, and Albert Magnuson were appointed to compose a full slate of officers for the forthcoming year starting June 10, 1960.

It was noted that several members from Los Angeles, and a number of others from the California State Polytechnic College at San Luis Obispo, 130 miles away, attended the meeting.

Prize Paper Contest Winners of Spokane Section Announced

Two members and two associate members are winners of the Spokane, Wash., Section Prize Paper Contest, held May 2.

The distribution of $100 in prizes to the winners, paper titles, and the presentation qualifying them for the competition are as follows:

First Prize—$40. Earl Hazen (M '56), "Extra-High-Voltage Single and Twin Bundle Conductors," presented at the 1960 Winter General Meeting.

Second Prize—$30. W. J. Sanders (M '59), "Laboratory and Field Evaluation of Connectors and Other Accessories for Aluminum Conductors in Severe Marine Environments," presented at the 1960 Winter General Meeting.

Third Prize—$20. G. G. Hespelt (AM '58), "Preliminary Design of Hydrological Data Telemetering Equipment," presented at the 1959 Summer General Meeting.

Fourth Prize—$10. R. A. Balch (AM '55), "A Control-Free Earth-Air Heat Pump," presented at the 1959 Summer General Meeting.

The Section Prize Paper Committee was composed of the following men: D. A. Colville, chairman; and Earl Baughn, Harold Martindale, and R. F. Doupe, judges.

AIME Secretary Receives Wayne State's Alumni Award

For distinguished achievement in the science of metallurgy, Dr. E. O. Kirkendall, secretary of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME), has received an Alumni Award from his alma mater, Wayne State University, Detroit, Mich.

E. O. Kirkendall

The citation for Dr. Kirkendall stated: "His research has brought him international fame as the discoverer of a phenomenon in diffusion in solid metals now known as the 'Kirkendall Effect.' His work has given impetus to the whole area of physics of the solid state and has stimulated numerous scholarly studies throughout the world based on concepts which he first presented."

Dr. Kirkendall received his B.S. degree from Wayne in 1934. He was a Fellow at the University of Michigan during 1934-35. In 1935, he received the M.S. degree in engineering, and, in 1938, the D.Sc. degree. First as an instructor, then as assistant professor, Dr. Kirkendall served on the Wayne faculty prior to becoming an AIME executive in 1946.

Previously the recipient of Alumni Awards from Wayne State University and the University of Michigan, Dr. Kirkendall is an honorary member of metallurgical societies in Great Britain, France, Germany, and Belgium, and is a member of Sigma Xi, Tau Beta Pi, and the American Society for Metals.

1960 Sperry Award Presented to F. D. Braddon

F. D. Braddon, creator of the gyrocompass that guided the atomic submarines *USS Nautilus* and *USS Skate* under the ice cap of the North Pole, was honored May 4 at Franklin Hall in Philadelphia, Pa., by four of the nation's leading engineering societies. He received the Elmer A. Sperry Award for outstanding contributions to the field of transportation.

Previous recipients of the award are: W. F. Gibbs, designer of the *S.S. United States;* D. W. Douglas, creator of the DC series of aircraft; and the teams that created the Volkswagen; the General Motors diesel-electric locomotive; and the British jet airplane, Comet I.

The 1960 award was presented at a joint meeting of the Franklin Institute and the Philadelphia Science Teachers Association by H. W. Pierce, a member of the Elmer A. Sperry Board of Award. He represented the four sponsoring societies: AIEE, American Society of Mechanical Engineers, Society of Automotive Engineers, and Society of Naval Architects and Marine Engineers.

At the meeting, Mr. Braddon spoke on "New Gyros for Our Submarines."

Mr. Braddon, sixth recipient of the award, is chief engineer of the Marine Division, Sperry Gyroscope Company.

He is the first Sperry employee selected for this honor which commemorates the achievements of Dr. E. A. Sperry, scientist, inventor, and founder of the Sperry Gyroscope Company.

Mr. Braddon, who joined Dr. Sperry's organization in 1929, was chosen for the 1960 award chiefly for his work in developing a gyroscope device, known as the Mark 19 Gyro-Compass, which guided the nuclear submarines *Nautilus* and *Skate* on their record-long voyages, including the first trans-polar passage under the Arctic ice cap.

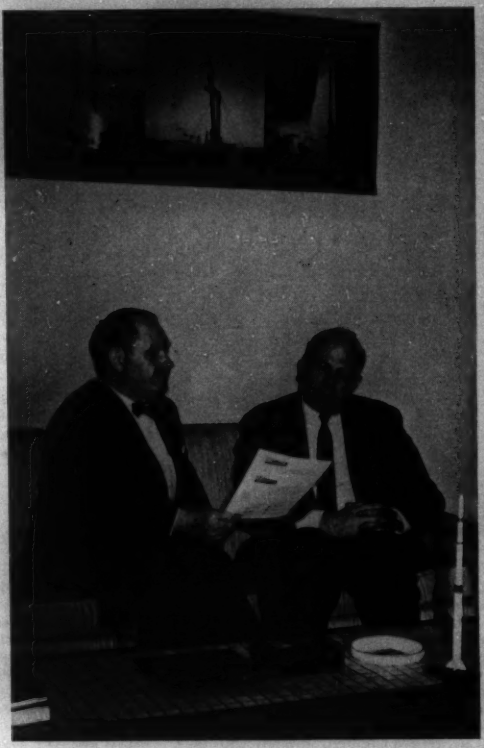
He began development of the Mark 19 shortly after World War II, when he was research director for marine equipment at Sperry Gyroscope Company.

His background includes 30 years of experience in the development of many kinds of gyros for marine and aircraft automatic pilots, controls, and instrumentation systems.

Mr. Braddon earned his M.E. degree at Stevens Institute of Technology in 1929. He has 43 issued patents and is the author of many papers on navigation.

His professional memberships include the American Society of Naval Engineers, Institute of Navigation, Society of Naval Architects and Marine Engineers, Propeller Club of New York, and American Management Association.

Professional Development Program Planners



DISCUSSING the First 5 Years Program sponsored by the Engineers' Council for Professional Development (ECPD) are: (*left to right*) Dr. T. K. Glennan, administrator of the National Aeronautics and Space Administration and president-on-leave of the Case Institute of Technology, and W. L. Everitt, dean of engineering of the University of Illinois and president of ECPD. Dr. Glennan and Dean Everitt met recently in Washington to discuss the importance of getting the most out of America's brainpower. In explaining ECPD's plan for helping young engineers, Dean Everitt said that too often there is a post-college slump in the careers of our young engineers. As an antidote for this probability, the ECPD is offering its "First 5 Years Program," which is designed to close the gap between college and the realities of earning a living.

Tau Beta Pi Selects Six Engineers for Fellow Awards

Six young engineers have been selected by Tau Beta Pi for graduate fellowship awards in 1960-61. The six men are:

R. L. Francis of Bluefield, W. Va. Honeywell-Tau Beta Pi Fellow No. 7. Mr. Francis will graduate in industrial engineering from Virginia Polytechnic Institute in June 1960. He will take advanced work in the operations research area of industrial engineering next year. His age is 21. He is also a member of Pi Delta Epsilon, Alpha Pi Mu, Omicron Delta Kappa, and Phi Kappa Phi honor societies.

A. J. DeVilbiss of Roanoke, La. Charles H. Spencer Fellow No. 5. Mr DeVilbiss will graduate in electrical engineering in June 1960 from Louisiana Polytechnic Institute. He will take advanced work in electrical engineering at the California Institute of Technology next year. His age is 21. He is also a member of Phi Kappa Phi and Kappa Tau Delta honor societies.

T. R. Schlax of Salem, Wis. Alumni Fellow No. 3. Mr. Schlax will graduate in electrical engineering in June 1960 from Marquette University. He will take advanced work in electrical engineering next year at Marquette University. His age is 21. He is also a member of Eta Kappa Nu and Pi Mu Epsilon honor societies.

B. L. Gregory of Phoenix, Ariz. Tau Beta Pi Fellow No. 144. Mr. Gregory will graduate in electrical engineering from Carnegie Institute of Technology in June 1960. He will take advanced work in electrical engineering at the Carnegie Institute of Technology next year. His age is 21. He is also a member of Eta Kappa Nu and Phi Kappa Phi honor socities and Sigma Alpha Epsilon fraternity.

B. G. Nimmo of St. Petersburg, Fla. Tau Beta Pi Fellow No. 145. Mr. Nimmo will graduate in mechanical engineering at Clarkson College in June 1960. He will take advanced work in thermal engineering next year. His age is 21. He is also a member of Pi Tau Sigma honor society and Lambda Iota fraternity.

W. C. Rochelle of Angleton, Tex. Tau Beta Pi Fellow No. 146. Mr Rochelle will graduate in aero-space engineering from the University of Texas in August 1960. He will take advanced work in aircraft and missile propulsion systems at the University of Texas next year. His age is 22. He is also a member of Sigma Gamma Tau honor society.

These six awards by Tau Beta Pi's Fellowship Board bring the total to 158 fellowships granted since the program was inaugurated in 1929. Stipends for the group are $1,800 each for the 9-month academic year. More than $147,000 in fellowship stipends will have been awarded by Tau Beta Pi in the 31-year-old program when this new group completes its graduate work in 1961.

Of particular interest is the 12th cooperative industry-Tau Beta Pi fellowship awarded to R. L. Francis. His stipend will be paid by a donation from the Minneapolis-Honeywell Regulator Company of Minneapolis, Minn., although his selection as a winner was made by the Fellowship Board in the same way and under identical rules as applied to regular Fellows. The Minneapolis-Honeywell Regulator Company joined with Tau Beta Pi in 1954-55 in offering its fellowship, and is giving its seventh fellowship now.

The Charles H. Spencer Fellowship, awarded for the fifth time this year, to A. J. DeVilbiss, is named for the former chief engineer of the Federal Government's Interstate Commerce Commission and Tau Beta Pi's national president during 1936-47. Mr. Spencer, who lives in Washington, D. C., made great contributions to Tau Beta Pi during his presidency and always was intensely interested in the professional development of young engineers. The Charles H. Spencer Fellowship in Tau Beta Pi is awarded to that stipend winner who has done most to advance the welfare of his own chapter of Tau Beta Pi and has contributed most to his own college.

The third Tau Beta Pi Alumni Fellowship, awarded this year to T. R. Schlax, results from accumulated donations by members, chapters, and friends of the Association who are interested in offering the benefits of the Fellowship Program to additional deserving young engineers.

All Tau Beta Pi fellowships are awarded on the competitive basis of high scholarship, campus leadership and service, promise of future development in the engineering profession, and need for financial assistance in graduate work. Applicants are members of Tau Beta Pi and winners may take their advanced study in any field of engineering and at any institution of their choice. The standing of this program is indicated by the fact that graduate schools

SPEAKER for this year's Steinmetz Memorial Program, Dr. L. M. Gilbreth (*left*) was presented with a gift of silver plate from J. C. White (*right*), chairman of the Schenectady Section, AIEE.
Black Studio, Inc.

all over the country customarily waive tuition and fees for Tau Beta Pi Fellows.

Tau Beta Pi's Fellowship Board, which met in New York City on March 29 to select the winners of this 27th program, consists of: P. H. Robbins, director of fellowships for Tau Beta Pi, executive director of the National Society of Professional Engineers, Washington, D. C.; R. S. Healy, retired engineer, formerly with the New York Telephone Company, New York City; J. C. Wagner, supervisor of industrial relations, The Texas Company, Beacon, N. Y.; E. A. Salma, assistant dean in charge of the engineering evening division, New York University, New York City.

Tau Beta Pi is a national engineering honor society which was founded at Lehigh University in 1885. It now has active chapters at 103 United States engineering colleges. It has initiated over 106,000 members in its 75-year history.

Dr. Gilbreth Is Speaker at Steinmetz Memorial Program

This year's Steinmetz Memorial Program address was delivered by Dr. L. M. Gilbreth, internationally known industrial engineer and management consultant. Dr. Gilbreth's talk, entitled "Management and Men," was carried on television by Station WRGB, Schenectady, N. Y., on Saturday evening, April 23.

This program was sponsored by the Steinmetz Memorial Foundation and the Schenectady Section, AIEE. The Steinmetz Memorial Foundation was established in 1925 in consideration of the outstanding technical and scientific ability possessed by Dr. Steinmetz and of his broad humane interests and varied public activities. The Foundation provides for the delivery and publication of public lectures by persons of eminence in honor of C. P. Steinmetz, whose personality and achievements will thus be recalled periodically.

Dr. Gilbreth is president of Gilbreth, Inc., a management and industrial engineering consulting firm in Montclair, N. J. The firm was founded by her late husband, F. B. Gilbreth, an efficiency expert and time and motion study authority. After his death in 1924, Dr. Gilbreth took over his work, expanded it, and ran the consulting firm. The impact of her work with Gilbreth, Inc., in the fields of management, time and motion study, and applying engineering to the humanities, has been internationally recognized.

In the introduction to her talk, Dr. Gilbreth noted that she and her husband both knew Dr. Steinmetz through their visits to General Electric at Schenectady.

Dr. Gilbreth had just returned from a meeting of the 12th International Congress of Scientific Management in Australia, and she told of the first meeting of this group in Czechoslovakia just after Dr. Steinmetz's death in 1923. She went on to describe the recent meetings in Australia where such subjects as management in industry, business, agriculture, home, and government were covered.

She stressed the point that management concerns itself with people not only by definition but by ethics. The early leaders in the management field were described as engineers who believed that it was their job to utilize the resources of nature and of human nature for the benefit of mankind.

A large portion of the Australia meetings was devoted to problems of the home and family, since so much of industry's effort goes into the great home market. In addition, it was emphasized that if the home is well managed, then the people who go out from this home carry with them a serenity and adaptability that makes them more useful in all their endeavors.

Dr. Gilbreth spoke of the importance of a manager first managing himself. Too often, this point is disregarded, since it seems so much easier to manage others than to manage ourselves.

Automation, a great power for good if properly used, but a danger if not so used, took up a portion of the Australia meetings. Dr. Gilbreth maintained that the people involved in automation must be considered as well as the technical aspects of the problems. The challenge is to prevent short term unemployment as a result of automation. In addition, while taking the drudgery out of jobs, we must be careful that we are not taking away some unseen, unappreciated satisfaction which the person doing the job had and which we cannot afford to take away without replacing it. In the long run, automation will result in more jobs and if properly handled, will reduce costs and increase production.

The question of shorter working time for people raised some serious questions. Have people really been given the education and training which will allow them to produce more in a shorter time? Do people know what to do with all the leisure time resulting from shorter working hours?

The talk ended on the note that a challenge is being presented to the educational systems of the world to educate well-rounded human beings who can share in a full life with other people, while at the same time educating people competent in the sciences—both exact and social.

APDA Convention Held May 6-7 in Riverside, Calif.

The American Power Dispatchers Association, Inc. (APDA), held its National Spring Meeting at the Mission Inn in Riverside, Calif., on May 6-7, with California Electric Power Company (CEP) dispatchers as hosts. Fred Niemeyer, CEP dispatcher and Association president, was in charge of arrangements.

Highlighting the meeting was a talk by W. T. Johnson, vice-president and assistant general manager of CEP, on "Power Pooling in the Southwest Area."

Field trips included a visit to Southern California Edison Company's Mill Creek No. 1 plant where the first 3-phase hydroelectric generator in the United States was installed in 1893. The group was also conducted on a tour through California Electric Power Company's new San Bernardino, Calif., steam plant.

S. H. Gold, electrical engineer for the CEP, addressed the dinner meeting in the evening on "What Voltage Dips Mean to the Engineer."

The Log, APDA biannual publication, was ready for distribution at the meeting.

Dispatchers from the Canal Zone, the City of Seattle, Arizona Public Service, Pacific Gas and Electric, and from the Southern California area attended.

Curriculum Considered in Biomedical Engineering

More than 85 participants representing engineering and medical education, industry, and Government attended the Symposium on Educational Frontiers in Biomedical Engineering, May 5-6, on the University of Vermont campus.

This symposium is the first to consider curriculum in the expanding professional field of biomedical engineering.

G. C. Riggle of the National Institutes of Health, program chairman for the symposium, noted that some 12 of 43 universities participating have existing or planned doctoral programs in the field, to which he referred as a recent one "in terms of organized training."

Dr. S. A. Talbot of Johns Hopkins University, also a member of the symposium program committee, spoke of the "growing complexity of biological and physiological sciences" as having created a need for "research partnership of these sciences with engineering concepts."

The symposium, initiated by the University of Vermont engineering faculty engaged in biomedical research with the Vermont College of Medicine, is sponsored by the University, the AIEE, the Institute of Radio Engineers, and the National Science Foundation.

The symposium "produced general agreement," according to Dr. Talbot, "that the biomedical engineer should be basically an engineer with a broad background in biology and biophysics."

A 3- to 4-year doctoral curriculum with 50% of its course content in engineering and the remainder in biology, chemistry, and biomedical techniques was recommended.

Speakers for the 2-day program represented the following universities: Columbia, Massachusetts Institute of Technology, Pennsylvania, Nebraska, Illinois, Brooklyn Polytechnic Institute, Iowa State, Drexel, Ohio State, Yale, Harvard, North Carolina State, Rochester, Johns Hopkins, and Vermont.

Industry and Government speakers included representatives of the General Electric Company, International Business Machines Corporation, Gilford Instruments, and the National Institutes of Health.

Dr. James Dow of Drexel Institute and the Presbyterian Hospital of Philadelphia told participants "there simply have not been enough men prepared to understand the deficiencies of instrumentation, appreciate its possibilities, or accept the implication of personal obsolesence that insistence on thorough preparation in the physical sciences holds for medical investigators not themselves so trained.

"As happens when any society stands still too long, change is being imposed on medicine from without."

He said that engineers "can contribute immeasurably to biological and physiological research simply in the application of known engineering principles and techniques to human problems."

In particular, he said, "biomedical engineers are needed to conceive, design and create the instrumentation necessary to continue the advance of the life sciences."

Stan Clay Photo

FIRST PLACE winner of the District 6 student paper competition, R. F. Stanfield (left), University of Wyoming, appears as he presented his paper, entitled "A Fully Automatic, Variably Programmed Telephone Dialer." Another student from the University of Wyoming assisted Mr. Stanfield with the demonstration during the presentation of the paper.

197 Delegates Attend District 6 Student Conference

The University of Denver in Denver, Colo., was host to the District 6 AIEE Student Branch Conference on April 22-23, 1960, with headquarters in the Student Union Building. About 197 delegates from eight universities attended the conference.

The general session was called to order at 9:00 a.m. on Friday by John Sanders, president of the Denver University branch of the AIEE. Chancellor C. M. Alter of the University of Denver gave the welcoming address. Following the welcoming address, the papers for the student paper competition were presented by students from six universities.

Friday afternoon, the delegates took a field trip to see the Arapahoe and Cherokee Power Plants of the Public Service Company of Colorado.

On Friday evening, the banquet was held with J. H. Foote, AIEE president, as the principal speaker. Mr. Foote, in his talk, stressed the importance of professional registration which engineers should do before they go into consultant work. He also showed picture slides of his recent trip to Russia. Many of his pictures covered Russian power plants, structures, and high-voltage lines.

The awards for the paper competition were presented during the banquet by Prof. Arlie Paige, chairman of the District Committee.

R. F. Stanfield of the University of Wyoming was first place winner with his paper, "The Fully Automatic, Variably Programmed Telephone Dialer." Mr. Stanfield received a cash award and an all-expense-paid trip to Atlantic City, N. J., to participate in the AIEE Summer General Meeting.

The second place winner was Stuart Mitchell from the South Dakota School of Mines. His paper was entitled "Two-Channel Record Playback Tape Preamplifier." The third place winner was Frederick Griffin from the University of Colorado. His paper was entitled "Janus, An Electric Nurses' Aid."

On Saturday morning, 125 delegates traveled to the Martin Company of Denver for a tour of the missile plant.

The final business meeting of the conference was held Saturday morning. District officers and student chairmen met for the purpose of comparing and discussing ideas. The District officers who attended this business meeting were: Max Kight, vice-president; Warren Wheeler, secretary; and Arlie Paige, chairman of the District Student Activities Committee.

Student Branch Counselor Retires After 30 Years' Service

A meeting bell and gavel was presented to the Student Branch at the Michigan College of Mining and Technology, Houghton, Mich., by the Northeastern Wisconsin Section, AIEE, in honor of Prof. G. W. Swenson, head of the electrical engineering department, at a banquet on May 6.

The presentation was made in recognition of the long service and retirement in June of Prof. Swenson, who served as branch counselor for 30 years, is a Fellow of the AIEE and a life member. He was chairman of the District 5 Student Activities Committee in 1937-38 and in 1958-59.

Prof. Swenson is a member of the American Society for Engineering Education and was chairman of the National Electrical Engineering Division in 1940. He is a past chairman of the North Midwest Section.

He is a member of the National Education Society, the American Association for the Advancement of Science, and of the National Advisory Board of Eta Kappa Nu.

Fall General Meeting Planners

ARRANGEMENTS for the 1960 Fall General Meeting to be held in Chicago, Ill., at the Morrison Hotel on October 9-14 are well under way. Officers and committee chairmen are shown at their May 5 meeting: (*front row, left to right*) F. D. Hurd, registration; J. J. Agosta, treasurer; E. C. Carlson, secretary; L. E. Randall, chairman; D. W. Gilman, vice-chairman; Mrs. G. L. Welch, ladies activities; G. L. Landgren, hotel arrangements; (*standing*) J. H. Enenbach, general session; J. L. Armbrust, technical program; J. W. Schneider, hospitality; J. A. Schwenke, trips and transportation; Thomas Donaldson, finance and budget; and I. E. Cooper, attending for D. R. Whitlow, Fall Frolics. Not shown in the photo are J. B. O'Brien, sale of papers; P. R. Cassidy, ticket sales; and H. A. Bergen, publicity.

General Committee Named for Summer General Meeting

Members of the General Committee for the next AIEE Summer General Meeting, to be held on the campus of Cornell University in Ithaca, N. Y., June 18-23, 1961, have been appointed by AIEE President J. H. Foote.

W. H. Erickson has been named chairman; C. J. Fitch, vice-chairman—secretary; R. E. Osborn, treasurer; J. P. Peterson, finance; M. G. Malti, program; S. Linke, housing; E. M. Strong, entertainment; C. L. Cottrell, properties; H. G. Smith, dining; D. Purdy, publicity; N. H. Bryant, registration; J. L. Rosson, sports; P. D. Ankrun, transportation; J. L. Cooney, Jr., trips; and Mrs. M. G. Malti, ladies program.

German Atom Forum To Discuss Nuclear Technique

The German Atom Forum has arranged, through the Work Assembly for Nuclear Technique, a special science lecture on the "Application of Nuclear Energy" to be held October 11-13, 1960, in Karlsruhe.

Prof. Dr. Balke, alliance minister for atom nuclear energy and water management, will be present to carry out the forum theme.

Reports and a panel lecture will consist of the following subjects: Reactor Technique, Isotopes in Research and Technique, Adjustments—and Measurement Technique, and Work Materials and Nuclear Technique Appurtenances.

The object of the meeting is to give the current status of nuclear technique in the republic.

Steel Frame Rises

THIS is another photo showing the construction of the United Engineering Center at First Avenue and 47th Street in New York. The picture shows the steel skeleton being erected to form the 20-story building. The new building will be equipped with highly automated elevators supplied by the Westinghouse Electric Corporation. R. H. Wagner, manager of the Westinghouse Electric Division, announced that the Turner Construction Company has awarded Westinghouse the elevator contract for the building.

Webster-International

Manhattan College Student Wins New York Area Contest

R. T. Modaferri of Manhattan College was judged first prize winner at the Metropolitan Joint Student Council AIEE-IRE (Institute of Radio Engineers) Prize Paper Competition, held April 29 at the Newark College of Engineering.

The Prize Paper Competition and presentation of awards was the main feature of the 6th Annual Student Activities Day sponsored jointly by IRE Region 3 and AIEE District 2. The program began at 2:15 p.m. with a welcome by the Newark College president, Dr. Robert Van Houten, and introductory remarks by Dr. A. B. DuMont on the significance in professional development of entering prize paper competitions. Dr. DuMont, a Fellow of the AIEE, is known for his substantial contributions to electronics and television. The moderator for the afternoon was P. D. Lenner of Columbia University, chairman of the Joint Metropolitan Student Council.

Four papers, selected on the basis of written presentation from the 12 submitted, were given in the competition. Mr. Modaferri's paper was entitled "New Ideas in the Synthesis of Pipe Organ Tones Using Electronic Circuitry" and was presented before an audience of 250 students, faculty members, and guests. The program was one of the first to be held in Weston Hall, a part of the new electrical engineering building at Newark College of Engineering. The first prize was a $500 scholarship for graduate work, or $150 in cash, and an all-expense-paid trip to the AIEE Summer General Meeting at Atlantic City, N.J. Mr. Modiferri's name will be added to the IRE perpetuating plaque which will be at Manhattan College for the 1960-61 academic year.

The other winning papers and their authors were:

A Special Purpose Analog Computer for the Solution of Integral Equations. *P. M. Brodie*, Stevens Institute of Technology (Second Prize—$100)

Applying Audio Dynamic Compression to High-Fidelity Magnetic Recording. *D. H. Friedman*, Brooklyn Polytechnic Institute (Third Prize—$50)

The Electrical Engineering Questionnaire. *J. R. Keller*, New York University (Fourth Prize—$25)

Following the competition was a tour of the Newark College campus and the awards dinner. The after-dinner speakers were Dr. R. H. Cook, dean of engineering

t Pratt Institute, who gave a challenging alk on undergraduate professional develpment, and S. P. Schackleton, assistant o the director of the Research Laboratory, W. L. Maxson Company, who spoke n professional development after graduation. Prize awards were presented by W. G. Vieth, chairman of the New York Section, AIEE, and G. D. Hulst, chairman of the Northern New Jersey Section, IRE.

The judges of the 12 written papers and 4 oral presentations were Joseph Reed, General Precision Laboratories, and C. A. Borgenson, Western Electric Company, representing IRE; T. F. Cofer, Western Union, and Winslow Palmer, Sperry Gyroscope Company, representing AIEE. Prof. R. W. Meola, Newark College of Engineering, and Dr. Haroun Mahrous of Pratt Institute, assisted in judging the oral presentations.

It was noted that a Manhattan College contestant has placed among the first three in five of the six annual competitions, and that New York University has been first in four of the six competitions. Eleven metropolitan area schools are represented on the Joint Council.

District 1 Students Meet May 6 at Union College

Historic Union College in Schenectady, N. Y., was the site of the District 1 Prize Paper Contest and Spring Student Meeting May 6.

Six student papers were presented by contestants from four District 1 schools. Two of the three prizes went to Union College contestants. The first prize was awarded to Michael Leeming for his paper "A Dynamic Characteristics Tracer Using a Single Barium Titanate Capacitor," and the third prize to Charles Martin for his paper "Construction and Operation of a Storage Tube Oscilloscope." The second prize went to Gerry Roome of Syracuse University for his paper "Solid-State Microwave Frequency Generation." The first prize was $100 and an all-expense-paid trip to the AIEE Summer General Meeting in Atlantic City, N. J.; the second prize, $50; and the third prize, $25.

Following a tour through the unusual formal garden at Union, the awards banquet was held. A welcome was given by Union College president, Dr. Carter Davidson, who pointed out that Union was one of the first three schools in the United States to have engineering education, and that when Dr. C. P. Steinmetz was head of the electrical engineering department, two thirds of the student body were in electrical engineering.

Prize awards were presented by L. C. Holmes, vice-president of AIEE District 1.

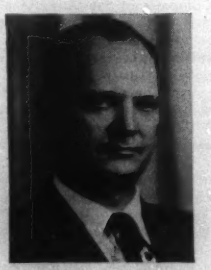
In charge of the program for the day were Prof. D. A. Buddenhagen, Union College AIEE Branch counselor; Alan Bensky, chairman of the AIEE-IRE (Institute of Radio Engineers) Joint Student Branch; and Prof. E. V. Kosso, of Syracuse University, chairman of the District 1 Student Activities Committee. Judges for the oral presentation of the papers were three AIEE members from the General Electric Company, Dr. G. C. Feth, J. W. Yetter, and C. C. Herskind.

Prof. F. P. Fischer, counselor at the University of Buffalo, was selected as chairman of the District Student Activities Committee for the coming year.

AIEE FELLOWS ELECTED

Board of Directors Meeting, April 21, 1960

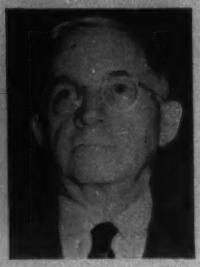
Marvin A. Baker (AM '42, M '48), manager of product engineering, direct current motor and generator department, General Electric Company, Erie, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to large rotating amplifying generators, d-c motors, and generators." Born in Pierson, Iowa, January 21, 1914, he was graduated from Iowa State College, now Iowa State University, with the B.S. degree in electrical engineering in 1935. He joined the General Electric Company, Schenectady, N. Y. in 1935, took the company training course, and served as head of development rectifier test before his transfer to the engineering department of the Motor and Generator Division in Fort Wayne, Ind., in 1937. His engineering and management assignments covered a wide range of d-c and synchronous motors and generators; he holds several patents on d-c machines. He designed a large 50-kw amplidyne exciter for steel mill application, and during World War II was given the responsibility for developing large high response amplidyne generators for defense applications. In 1954, Mr. Baker was assigned the responsibility for design and development of General Electric's line of 1-150 hp Kinamatic d-c motors and generators and is presently serving as manager—engineering of this line. He helped to establish the new industrial standards of the National Electrical Manufacturers Association, and now serves on the scope committee of the integral hp group. Mr. Baker is a registered professional engineer in the State of Indiana and a member of Tau Beta Pi and Eta Kappa Nu. He is a member of the AIEE Rotating Machinery Committee (1950-60).



M. A. Baker

Frank Marshall Clark (AM '24, M '48), consulting engineer—insulation, General Electric Company, Schenectady, N. Y. has been transferred to the grade of Fellow in the AIEE ". . . for contributions to development of electrical insulation through the application of chemical principles." He studied chemistry at Wesleyan, Yale, and Princeton Universities, and taught chemistry at Wesleyan, Allegheny College, Princeton, and Lafayette College. In 1923, he joined General Electric, where he has served, successively, as a section manager in charge of insulation research and development and as assistant engineering manager of the laboratory in the Transformer Division, as staff assistant and technical consultant on insulation to the manager of the apparatus department, as division engineer in the General Engineering Laboratory, and in his present position as consulting engineer on insulation. Some 123 United States patents have been assigned to him. Mr. Clark has three times been awarded the Coffin Award by the General Electric Company, in 1932, 1934, and 1950, for his technical accomplishments in the development of new insulating materials and treating processes leading to the "improvement in quality and the reduction in the cost" of capacitors and transformers. Mr. Clark has represented United States National Committees as technical advisor on liquid dielectrics in the International Electrotechnical Commission since 1948 and as United States representative to the Congress for High-Voltage Research since 1953. He is a member of Phi Beta Kappa, a Fellow in the American Institute of Chemists, and a member of the American Chemical Society, the American Electrochemical Society, and the American Society for Testing Materials. He is a founder of the annual Insulation Conference, now sponsored by the National Research Council. Mr. Clark has served on the following AIEE Committees: Electrophysics (1927-29), Electrochemistry and Electrometallurgy (1933-36), Research (1938-45), Basic Sciences (1948-53), Dielectrics (1955-58), and Electrical Insulation (1958-60).

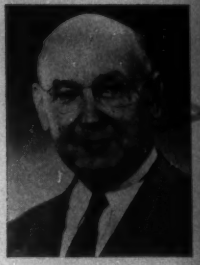
F. M. Clark



W. J. Creamer

Walter Criley

H. H. Davenport



H. F. Gidlund

Walter Joseph Creamer (M '39), head of the electrical engineering department, University of Maine, Orono, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to electrical communication and to electrical education and literature." Mr. Creamer was born March 3, 1896, in Penobscot, Maine. He received the B.S. degree in electrical engineering in 1918 and the electrical engineering degree in 1921, both from the University of Maine. During 1918-19, he was employed by Western Electric Company, now Bell Telephone Laboratories, in New York City. His early experience in broadcasting included the operation, in 1925-27, of the University of Maine station WGBX and the construction and operation of station WABI in Bangor, Maine, in 1928-34. These were the first broadcast stations in the state. Since 1919, he has served the university, successively, as instructor in drawing, instructor in electrical engineering, assistant professor in electrical engineering, associate professor in electrical engineering, associate professor in electrical communications, professor of communication engineering, and since 1945, as head of the department of electrical engineering. During 1923-27, he was assistant dean or acting dean of the College of Technology and, in 1927-41, served as director of Freshman Week. In the decade 1920-30, he developed and taught some of the earliest college courses in electronics, electroacoustics, and wire communications. During World War II, he was in charge of War Training Courses in radio communication for the State of Maine. Mr. Creamer is a member of Tau Beta Pi and Phi Kappa Phi, a member of the American Society for Engineering Education, and a senior member of the Institute of Radio Engineers.

Walter Criley (AM '38, M '46), professor of electrical engineering at Vanderbilt University, Nashville, Tenn., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to personal professional development of engineering students." He was born May 18, 1900, in Philadelphia, Pa., and educated at the University of Pennsylvania, from which he received the B.S. degree in electrical engineering in 1921 and the electrical engineering degree in 1940. During 1921-22, Mr. Criley was a transmission tester for the American Telephone and Telegraph Company in New York, N. Y. The following year, he was an instructor in electricity at the Georgia Institute of Technology, Atlanta, Ga. He was an instructor in electricity at the University of Pennsylvania during 1923-25. Mr. Criley was employed by the Pennsylvania Power and Light Company, Allentown, Pa., as cost engineer for recent railway properties in 1925-30. For the next 7 years, he taught electricity at the Rochester Institute of Technology, Rochester, N. Y. In 1937-47, Mr. Criley was an engineer for the Rochester Telephone Corporation. He became associate professor of electrical engineering at Vanderbilt University, Nashville, Tenn., in 1947 and professor in 1955. He is a registered professional engineer of the State of New York and a member of the Tennessee Chapter of the National Society of Professional Engineers. Mr. Criley is a member of the American Society for Engineering Education. He has served on the following AIEE Committees: Student Branches (1953-59), Sections (1953-58), and Membership—District No. 13 representative (1959-60). He is a past chairman of the AIEE Rochester Section (1943-44) and Nashville Section (1951-52), and has been nominated for the office of vice-president, District 13 (1960-62).

Howard Hutton Davenport (AM '38, M '46), outside plant and transmission and protection engineer, Southwestern Bell Telephone Company, Little Rock, Ark., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to military and civil telephone communications." Mr. Davenport was born July 22, 1910, in Houston, Texas, and received the B.S. degree in electrical engineering from the University of Texas in 1932. For the next 4 years, he performed drafting and surveying tasks for various engineering organizations in San Antonio, Texas. In 1936, he joined the Southwestern Bell Telephone Company in San Antonio and has been with this organization since that time. During 1936-41, he worked in the plant and engineering phases of the telephone business. During 1941-45, he was on military leave of absence from the telephone company, and served as signal officer with the U. S. Army. He returned to the Southwestern Bell Telephone Company in 1946, and for the next 5 years had the responsibility for review and engineering design of telephone plant for the Western half of Texas. In 1951, he was assigned the responsibility for determining the communication requirements for Department of Defense establishments in the State of Texas and was directly responsible for the furnishing of these requirements and the contractual negotiations for these services supplied to the Department of Defense. Since 1955, he has been in his present position. In this capacity, he is in responsible charge of an engineering group which designs all types of intercity communications in the State of Arkansas. He is a member of Eta Kappa Nu, a registered professional engineer in Arkansas and Texas, and is a member of the Arkansas and National Society of Professional Engineers.

Hilding Ferdinand Gidlund (AM '35, M '42), superintendent of the electric distribution department, Public Service Company of Colorado, Denver, Colo., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to development and operation of a large electric distribution system." Mr. Gidlund was born in Haparanda, Sweden, on July 10, 1902, and studied electrical engineering at Ohio State University and advanced a-c theory at Colorado University. In 1918, he joined the Automatic Reclosing Circuit Breaker Company. Two years later, he became associated with the General Electric Company as a switchgear designer, a position he held for 2 years. Later, he accepted a position with the Public Service Company of Colorado, where he advanced from substation design engineer to substation engineer and then, in 1956, to superintendent of substations. In this position, he was responsible for the construction and maintenance of all of the Public Service Company substations and switching stations. In 1959, he was elevated to the position of deputy superintendent of distribution. He gradually assumed the duties of the superintendent of electric distribution, a position he now holds. He is a member of the Transmission and Distribution Committee of the Edison Electric Institute. Mr. Gidlund has served on the following AIEE Committees: Substations (1948-57), Membership (1955-57), and Sections (1957-58). He has served as secretary-treasurer and as chairman of the Denver Section and a term as secretary of AIEE District 6.

Gerhart W. Heumann (AM '44, M '46), senior engineer on power utilization problems, General Electric Company, Schenectady, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to design of magnetic controls." He was born April 26, 1900, in Luckenwalde, Germany. He studied elec-

trical engineering at the Technical University in Dresden, Germany. In 1923, he joined Siemens-Schuckert Company, Berlin, Germany, as an application engineer, assigned to problems of industrial power distribution and utilization. In 1926, he joined the Westinghouse Electric Corporation as application engineer on power transmission problems. The following year he became liaison engineer in the Schenectady, N. Y., office of the German AEG Company. He entered the employ of the General Electric Company in 1931 in the industrial control engineering department and worked on the design and development of motor controllers for industrial applications. In 1956, he transferred to the Industrial Engineering Section of the Apparatus Sales Division. He is a registered professional engineer of the State of New York, an associate member of the National Electrical Manufacturers Association, and a member of the American Standards Association. He is an advisor to the United States National Committee of the International Electrotechnical Commission on controlgear. Mr. Heumann has served on the following AIEE Committees: Industrial Control (1947-53, chairman 1949-51); Standards (1949-50); Technical Program (1949-50); Industry Division (1949-60, chairman 1954-56); Safety (1951-54); Technical Operations (1954-59); and Joint Division Committee on Automation and Data Processing (1956-60, chairman 1956-59).

Ray Devere Jones (AM '30, M '47), liaison engineer, Fort Wayne Laboratory, General Electric Company, Fort Wayne, Ind., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to extended range and life of small motors, generators, and dynamotors for military application." He was born September 2, 1903, at Garrett, Ind., and graduated from Purdue University in 1925 with the B.S. degree in electrical engineering. Mr. Jones has been associated with General Electric in Fort Wayne since 1925, mainly in various phases of design engineering and supervision of design engineering of small electric motors and generators. In 1937, he was assigned to head up the Direct-Current and Specialty Motor Section of the fractional horse power motor department of the company. He is responsible for General Electric's first line of amplidyne generators and motor generator sets. Other design work under his direction included dynamotors for airborne radio equipment and General Electric's first line of motors designed specifically for aircraft use. After World War II, the work performed under his direction included many designs of 400-cycle motors for aircraft use. Work was contributed under his direction toward the national standardization of d-c and 400-cycle aircraft motors. He co-ordinated the development of motors for very high ambient temperatures, and was responsible for inaugurating extensive work in the determination of temperature distribution in electromagnetic machinery by means of thermal analog computer. In 1946, he was cited by the American Standards Association for his contribution to the American War Standards for Dynamotors. At that time, he also received General Electric's Charles A. Coffin Award for the development of a dynamotor with many new and advanced concepts for the powering of a then new high-power radio transmitter for airborne use. Mr. Jones served on the AIEE Air Transportation Committee (1947-58). He was chairman of the Fort Wayne Section (1951-52).

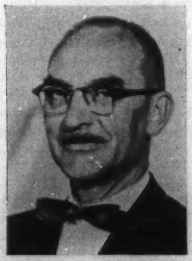
J. Harold Karr (AM '32, M '46), division products manager, universal and d-c motors, Robbins & Myers, Inc., Springfield, Ohio, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to design of electric motors and automotive directional signals." Mr. Karr was born in Enterprise, Kans., on March 17, 1909. He received the B.S. degree in 1930 from Kansas State College and the M.S. degree in 1935 from Purdue University, both in electrical engineering. He served as instructor and assistant professor of electrical engineering at Purdue University during 1930-1944, except for a year's leave of absence, in 1941-42, to work for Robbins & Myers, Inc., as a design engineer. He was responsible for the design of a line of d-c aircraft motors. In addition to teaching at Purdue, he was associated with the Engineering Experiment Station where he developed testing procedures and test equipment for automotive directional signals in the State of Indiana. In 1944, he became assistant chief engineer at Robbins & Myers, and for the next 12 years was responsible for the design of universal motors and motor parts, d-c motors and generators, high-frequency alternators and motor parts, and single-phase appliance motors. He was advanced to division products manager in 1956. Mr. Karr is a member of Eta Kappa Nu, Sigma Tau, and Phi Kappa Phi. He has served on the AIEE Constitution and Bylaws Committee (1953-58), and Rotating Machinery Committee (1955-60).

Marvin Lee (AM '35, M '41), president, Burndy Corporation, Norwalk, Conn., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to engineering development of electrical connectors and connector tools." Mr. Lee was born on March 31, 1901, in Brooklyn, N. Y., and received the electrical engineering degree in 1922 from the Polytechnic Institute of Brooklyn in 1922. After some previous experience with Consolidated Edison Company, New York, and in the field of electrical contracting, he joined Burndy Corporation in 1924 as a design engineer. Under his direction, the variety of electrical connector types offered to the electric power industry was greatly expanded to include those needed in generating plants, substations, transmission lines, distribution lines, house services, underground distribution, and heavy industrial wiring. One of his developments covered the design of hand operated portable hydraulic tools that made it possible to install pressure applied connectors in manholes underground and on overhead lines with great economy. He was elected a director of Burndy Corporation in 1927 and appointed chief engineer in 1935. In 1947, he was elected executive vice-president, a post he held until 1959 when he was elected president. At the same time, he assumed the post of president, Burndy Canada Ltd., Ont., Canada, and president, Burndy Electra S.A., Antwerp, Belgium. Mr. Lee is a registered professional engineer in New York and Connecticut and a member of Tau Beta Pi and Eta Kappa Nu. He is a trustee of the Polytechnic Institute of Brooklyn, trustee of the Burndy Library, and a member of the History of Science Society, the American Ordnance Association, and the Marine Historical Association.

Stanley Blair Lent (M '43), superintendent of power, Metropolitan Transit Authority, Boston, Mass., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to transit system electrification and engineering management." He studied at Northeastern University and at the Lowell Institute of the Massachusetts Institute of Technology. He was employed by the Boston Elevated Railway Company in the Electrical Engineering Division in 1922 and assigned to relay and meter testing. In 1938-39, he was in responsible

G. W. Heumann

R. D. Jones



J. H. Karr

Marvin Lee

S. B. Lent

M. R. Lory

F. W. McCloska

H. J. B. Nevitt

charge of a laboratory where electrical, mechanical, and chemical inspection, testing, and analysis of equipment and materials, and calibration and standardization of instruments and meters were conducted. In 1945, he was appointed chief electrical engineer of the Boston Elevated Railway, a position he retained when this railway operation became the Metropolitan Transit Authority. He was advanced to assistant superintendent of power and chief electrical engineer in 1953, and to superintendent of power in 1954. Mr. Lent is a registered professional engineer in the State of Massachusetts. He is a member of the permanent advisory council of the Lowell Institute School, and served on the executive committee of the United States National Committee of the World Power Conference (1951-52). He is a member of the American Transit Association, the National Society of Professional Engineers, the American Ordnance Association, and the American Standards Association. Mr. Lent has served on the AIEE Land Transportation Committee (1948-60).

Marion Richards Lory (AM '40, M '48), engineering manager, large rotating apparatus department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to design of large synchronous motors and electric couplings." Mr. Lory was born March 5, 1905, in Boulder, Colo. He received the B.S. degree from Colorado State University in 1927 and the M.S. degree in 1928 from the Massachusetts Institute of Technology, both in electrical engineering. Since 1928, he has been engaged continuously by Westinghouse. Upon completion of graduate student training with the firm, he entered the power engineering department where he became a designer of synchronous motors. He designed the two 86,000-hp motors that are part of the drive of the propulsion wind tunnel at the Arnold Engineering Development Center at Tullahoma, Tenn., and the four 65,000-hp pump motors at Grand Coulee Dam, Wash. During World War II, he specialized in marine propulsion drives and designed motors for a submarine tender, Coast Guard cutters, oil tankers, attack transports, and cargo vessels. He pioneered in the application of electric couplings, and designed large electric couplings used in the propulsion systems of cargo vessels, large tugs, ammunition carriers, and a ferry. In 1946, he became manager of the A-C Motor Section of what later became the large rotating apparatus department. In 1956, he became manager of A-C Motor and Generator Engineering, and in 1957 was appointed engineering manager. He is a registered professional engineer in the State of Pennsylvania. Mr. Lory has served in the AIEE as chairman of the Electric Coupling Subcommittee (1949-51), chairman of the Synchronous Machinery Subcommittee (1951-53), and chairman of the Rotating Machinery Committee (1959-60).

Fred Walter McCloska (AM '31, M '46), partner in charge of the nuclear department, Sargent & Lundy, Engineers, Chicago, Ill., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to design and application of electric equipment to power systems industrial and nuclear plants." He was born July 8, 1908, in Chicago, Ill. and was educated at the Illinois Institute of Technology from which he received his B.S. degree in electrical engineering in 1929. After graduation, he took the Commonwealth Edison Company's student training course, and later was assigned to the Chicago District Electric Generating Corporation as an engineer on power plant operation problems. He became associated with Sargent & Lundy in 1942 as an electrical engineer on the design of generating stations. In 1954, he was made a member of the firm. With Sargent & Lundy, he was responsible for the electrical design of approximately 4.4 million kw of generating capacity and 4.8 million kva of substation capacity of which three substations are for 345-kv operation. He was chairman of the committees which determined and co-ordinated the power supplies for both the Paducah and Portsmouth gaseous diffusion plants of the Atomic Energy Commission. Mr. McCloska has been active in the nuclear reactor field since 1946, and was placed in charge of Sargent & Lundy's nuclear work in 1959. He is a registered professional engineer in the States of Illinois, Ohio, Indiana, and Kentucky, and is a member of the American Nuclear Society, the Western Society of Engineers, and Eta Kappa Nu. He has served on the AIEE Switchgear Committee (1949-60).

Henry John Barrington Nevitt (M '48), consulting engineer, Ericsson Telephone Sales Corporation, Rio de Janeiro, Brazil, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to high quality international communication systems in Latin America." Born June 1, 1908, in St. Catherines, Ont., Canada, Mr. Nevitt studied electrical engineering at the University of Toronto, specializing in radio technology, and received the B.S. degree in 1934. He studied telephone communications at McGill University, Montreal, Que., Canada, and obtained the M.E. degree in 1945. His professional career began in 1934 as manufacturing engineer at Northern Electric Company, Montreal. In December 1939, he joined Canadian Pacific Telegraph, Montreal, as equipment engineer in charge of long distance telephone, telegraph, and radio program facilities for Eastern Lines. In 1944, he became staff engineer for the Radio Corporation of America (RCA), assigned to development of frequency-shift radio diversity receiving system for the Bureau of Ships, U.S. Navy. In 1945, he was advanced to executive engineer of the RCA International Division. During 1946, he engineered the first permanent multichannel telephone and telegraph microwave installations in Latin America for naval applications in Argentina and Brazil. Mr. Nevitt accepted his present appointment in 1947. He initiated and was mainly responsible for the first commercial vhf multichannel carrier telephone and telegraph facilities, over a propagation path approximating 150 miles without repeaters, between Bogota and Medellin, Columbia; the first 960-channel capacity co-axial cable telephone system in Latin America, installed between Sao Paulo and Santos, Brazil; and the first carrier and radio terminal facilities for Brasilia, new capital of Brazil. Mr. Nevitt is a senior member of the Institute of Radio Engineers, and is a member of the Engineering Institute of Canada, the Institution of Electrical Engineers (Great Britain), the American Association of Railroads, the American Association for the Advancement of Science, the Associãcao Brasileira de Telecomunicações, and Sigma Xi.

Jay Wilfred Picking (AM '43, M '45), manager, Control Division, Reliance Electric & Engineering Company, Cleveland, Ohio, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to development of automation by means of electronically controlled systems." He was born June 29, 1905, in Somerset, Pa., and received the electrical engineering degree in 1927 from Lehigh University. After graduation, he took a position with Re-

liance Electric and Engineering as a cadet engineer. He was later assigned to sales and application engineering in the New York District where he was instrumental in promoting the application of many synchronized adjustable speed drive systems to the paper, textile, chemical, and plastics industries. In 1943, Mr. Picking returned to the Home Office in Cleveland where he established an electronic development group and perfected the first electronic control systems used by his company. In 1945, the electronic development, the magnetic control, and the packaged drive engineering were combined into a single engineering department in which he served as manager of engineering. Mr. Picking was promoted to the position of manager of the Control Division in 1957. In this position, he is responsible for the complete operation of engineering and manufacturing the controls marketed by the company. He has served on the following AIEE Committees: Industrial Control (1945-60, chairman 1957-59); Industry Division (1957-60); Automation and Data Processing (1957-60); and Research (1959-60).

Irvine Emerson Ross (M '44), manager—engineering, specialty motor department, General Electric Company, Fort Wayne, Ind., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to development of commutations at high altitudes." He was born September 28, 1908, in Needham, Mass., and studied electrical engineering at the Massachusetts Institute of Technology from which he was awarded the B.S. degree in 1930 and the M.S. degree in 1931. He was employed by the Delco Products Company, Dayton, Ohio, in 1931-41 as a design engineer. During 1941-44, he was a research associate in the Radiation Laboratory of the Massachusetts Institute of Technology. The following 2 years, he was technical advisor to the Aircraft Electrical Council of the National Electrical Manufacturers Association. As chief engineer for the Victor Electric Products Company, Cincinnati, Ohio, he designed and manufactured shaded pole motors, ventilators, and fans. In 1948, he became assistant division engineer of General Electric in Fort Wayne, and in 1951, division engineer. The following year, he was assigned to his present position of manager—engineering in the specialty motor department. During 1942-44, he was a consultant to the National Defense Research Committee of the Office of Scientific Research and Development, assigned to co-ordinate and guide national activity among motor manufacturers, brush manufacturers, testing laboratories, airframe firms, and military agencies in coping with the problem of brush life at altitude. For effective services given during World War II, he was awarded a citation by the U. S. Office of Scientific Research and Development. Mr. Ross was named "Citizen-Engineer of the Year" by the Fort Wayne Technical Societies for the year 1958. He is a registered professional engineer of the State of Indiana, and a member of the Institute of Aeronautical Sciences.

Clarence Fred Schwan (AM '37, M '45), chief mechanical engineer, Reliance Electric and Engineering Company, Cleveland, Ohio, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to design of rotating machinery, especially for high-frequency induction heating." He was born August 21, 1903, in Cleveland, Ohio, and attended Ohio State University from which he graduated in 1936 with the degree of B.S. in electrical engineering. Previous to graduation, he was employed for one year by the Apex Electrical Manufacturing Company, Cleveland, as a design engineer. After graduation, he continued in the same capacity with Apex where he worked with fractional horse power motors. In 1936, he was associated with the Peerless Electric Company of Warren, Ohio, as assistant to the chief engineer. In 1942, he joined the Ohio Crankshaft Company, Cleveland, as special project engineer in charge of developing a line of high-frequency inductor alternators for use in the induction heating field. When he was employed by the Reliance Electric and Engineering Company in 1948, he continued in the same activity and completed the development of a line of vertical high-frequency inductor alternators up to 350-kw capacity. Mr. Schwan holds eight patents, chiefly in the field of high-frequency equipment. In 1943, he was made senior engineer in charge of mechanical development at the company's Ivanhoe Plant. In this capacity, he was responsible for the mechanical design of a line of D-C motors and generators up to 250-hp output. He also designed a line of dynamometers including the largest high-speed explosion-proof dynamometer built at the time it was developed. In 1957, he was appointed chief mechanical engineer with staff responsibilities for mechanical design in all divisions of the company. His duties as chief mechanical engineer include preparation of mechanical design procedures and consultation on mechanical problems. Mr. Schwan is a registered engineer in the State of Ohio and a member of the American Society of Mechanical Engineers.

Gareth Geraint Somerville (AM '39, M '49), manager—Process Development Laboratory, distribution transformer department, General Electric Company, Pittsfield, Mass., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to improvement of magnetic cores for power transformers." Mr. Somerville was born January 30, 1906, in Troy, Mo. He studied at the University of Kansas from which he received the B.S. degree in electrical engineering in 1929 and the electrical engineering degree in 1933. During 1929-30, he was a student engineer at the General Electric Company, Schenectady, N. Y. For the next 3 years, he was a development engineer for General Electric in Pittsfield, Mass. Mr. Somerville was advanced to welding engineer in 1933, and for 11 years was responsible for arc welding development and application in the Pittsfield plant. He developed a new self-operating arc welding process and introduced it into manufacturing of apparatus, for which he was awarded the company's Charles A. Coffin Award in 1934. In 1944, he was promoted to section supervisor—magnetic core development, responsible for the magnetic core development of the Transformer Laboratory. Mr. Somerville originated and developed a new style of magnetic core for transformers which made a major change in the design and economy of a large line of power transformers. For this, he was again presented the Coffin Award in 1948. He assumed his present position of manager—Process Development Laboratory in 1951. This laboratory is responsible for the development of new and improved manufacturing processes for distribution transformers. He is a registered professional engineer of the State of Massachusetts.

Charles Rowe Vail (AM '38, M '45), professor and chairman, department of electrical engineering, Duke University, Durham, N. C., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to electrical engineering teaching and to synthetic insulations." Dr. Vail was born October 16, 1915, in Glens Falls, N. Y. In 1937, he graduated from Duke University with the B.S. degree in electrical engineering, and in 1946 and

J. W. Picking

I. E. Ross

C. F. Schwan

G. G. Somerville

C. R. Vail

1956 he received the M.S. and the Ph.D. degrees, respectively, in electrical engineering from the University of Michigan. Dr. Vail was employed by the General Electric Company in 1937-39, and during the summers of 1940-41 and 1949. He joined the faculty of Duke University as an instructor in electrical engineering in 1939, and was advanced to the rank of assistant professor in 1945, to associate professor in 1952, and to professor in 1957. During 1953-56 he served as executive officer of the department of electrical engineering, and since that time he has held the position of department chairman. Dr. Vail has served as a consultant for the Wright Machinery Company Division of Sperry-Rand and the General Electric Company. During 1952-58 he was a consultant in the Solid-State Division of the U. S. Naval Research Laboratory. Currently, he serves as a consultant for the Research Triangle Institute of North Carolina, and is directing research in dielectric breakdown and in superconducting circuitry in his department at Duke University. Dr. Vail is a senior member of the Institute of Radio Engineers, a member of the American Society for Engineering Education, the American Association of University Professors, Phi Beta Kappa, Sigma Xi, Tau Beta Pi, Eta Kappa Nu, Pi Mu Epsilon, Phi Eta Sigma, and Omicron Delta Kappa. He is a registered professional engineer in the State of North Carolina. He is past secretary-treasurer (1952-53) and past chairman (1953-54) of the North Carolina Section, AIEE, and has served on the following AIEE Committees: Basic Sciences (1958-60); Electrical Insulation and its forerunner, Dielectrics (1955-60); Education (1958-60); Student Branches (1957); and Membership (1954-1958). He was District 4 vice-chairman of the Membership Committee for 1954-55, and served as counselor for the Duke Student Branch of AIEE in 1952-55.

AIEE PERSONALITIES

C. T. Abbott (AM '41, M '47) has been elected vice-president—operations of the New England Gas and Electric Association. **M. P. Griffith** (AM '54) has been appointed assistant vice-president of the Association. Mr. Abbott, who joined the system in 1930, was appointed electrical engineer in 1940, and chief electrical engineer in 1956. He has also been a director of the corporation since 1958. Mr. Griffith joined the system in 1954 as senior staff assistant.

G. R. Addy (M '57), engineer for the Attleboro Electric Company of Attleboro, Mass., has been promoted to superintendent of distribution. Mr. Addy was formerly an engineer for the Narragansett Electric Company of Providence, R. I.

Members of the Board of the new Wire and Cable Division of the National Electrical Manufacturers Association include: **D. E. Allen** (AM '23, Member for Life), executive vice-president, Anaconda Wire and Cable Company; **H. T. Brinton** (AM '23), president, Phelps Dodge Copper Products Corporation; **C. W. Higbee** (M '37), assistant general manager, Kaiser Aluminum & Chemical Corporation—Electrical Conductor Division; **E. L. Robinson** (AM '28, M '30), vice-president, Crescent Insulated Wire & Cable Company; and **W. J. Shea** (AM '40), vice-chairman of the Board, Paranite Wire & Cable Division, Essex Wire Corporation.

S. J. Angello (AM '42, M '51) has been appointed manager of molecular electronics programs for the Westinghouse Electric Corporation. Dr. Angello is based in Baltimore, Md., in the engineering department of the Air Arm Division. He was formerly project manager of the Westinghouse thermoelectric program, located at the new products laboratories in Cheswick, Pa. He has served on the AIEE Solid State Devices Committee (1955-60, chairman 1957-59) and Science and Electronics Division Committee (1957-60).

E. W. Baker (AM '40, F '51) has been named general manager, equipment engineering, of the Western Electric Company in New York. He was formerly manager of the company's air defense engineering services.

D. R. E. Barnaby (AM '46, M '48) recently joined Eitel-McCullough, Inc., San Carlos, Calif., as manager of the newly formed Parts Division. Prior to joining the manufacturer of Eimac electron-power tubes, Mr. Barnaby was plant manager for Line Material Industries of South Milwaukee, Wis.

S. B. Batdorf (M '60), former director of research for Lockheed Electronics Company's Newport Division, has joined Aeronutronic, a division of Ford Motor Company, as manager of product planning for range systems operations.

H. A. Bergen (AM '51) has been named a vice-president of Burson-Marsteller Associates, Inc., Chicago, Ill. Mr. Bergen, formerly an account supervisor, will remain in the firm's Chicago, Ill., office. He has served on the AIEE Industrial and Commercial Power Systems Committee (1954-60) and Periodicals and Transactions Committee (Central vice-chairman, 1959-60).

L. V. Berkner (AM '29, F '47), president of Associated Universities, Inc., in New York, has been elected to a 4-year term as treasurer of the National Academy of Sciences.

J. H. Blankenbuehler (AM '31, F '48), design engineer, Hobart Brothers Company, has been elected vice-president of the American Welding Society.

M. H. Borland (AM '48, M '55) has been promoted to the new post of general power superintendent of the Mead Corporation, Chillicothe, Ohio, Division. He is responsible for steam and electric power generation and electrical maintenance. Mr. Borland was previously superintendent of electric power.

M. M. Brandon (AM '28, M '44), president of Underwriters' Laboratories, presided at the Electrical Section session held in conjunction with the annual meeting of the National Fire Protection Association, on May 16 at the Queen Elizabeth in Montreal, Que., Canada. A report of progress on machine tool electrical standards was made by **R. L. Lloyd** (AM '37, M '46) of the National Bureau of Standards. **H. H. Watson** (M '47) of the General Electric Company discussed the Association's Committee on Trailers' provisions for electrical wiring of mobile homes. Mr. Brandon has served on the following AIEE Committees: Domestic and Commercial Applications (1943-51, chairman 1947-49), Safety (1944-60), Standards (1944-60, chairman 1952-54), and Technical Program (1947-52, chairman 1951-52). Mr. Lloyd is a member of the following AIEE Committees: Safety (1943-60, chairman 1959-60), Technical Operations (1959-60), Nuclear Congress and Nucleonics (1959-60), System Engineering (1959-60), and Standards (1959-60). Mr. Watson has served on the AIEE Safety Committee (1947-60), chairman (1957-59) and Domestic and Commercial Applications (1952-60).

M. M. Brandon (AM '28, F '44) has been re-elected president of Underwriters' Laboratories, Inc., Chicago, Ill. **K. S. Geiges** (AM '31, F '51) and **H. B. Whitaker** (AM '37, M '51) have been re-elected vice-presidents.

C. R. Burrows (AM '26, F '45) has joined Page Communications Engineers, Inc., a subsidiary of Northrop Corporation, Washington, D. C., as vice-president and director of research and development. Prior to joining Page, Dr. Burrows was vice-president—engineering for Radiation, Inc., Melbourne, Fla. He has served on the AIEE Research Committee (1947-60).

George Carp (AM '49, M '55) has been appointed chief engineer of the Connecticut Telephone & Electric Corporation of Meriden, Conn., a subsidiary of the National Pneumatic Company, Inc., Boston,

Mass. He directs development contracts to the electronics industry and proprietary product engineering. Mr Carp was previously technical director for the York Research Laboratories and director of electronic design for the Semi-Conductor Division of the Sperry-Rand Corporation.

P. P. Cartier (AM '56) has been promoted to project engineer in the Advanced Systems Development Division of International Business Machines, Pougkeepsie, N. Y. He was formerly associate engineer.

R. C. Cheek (AM '42, M '47) has been appointed director of business systems application, Westinghouse Electric Corporation, Pittsburgh, Pa. Mr. Cheek was formerly manager of the industrial electronics department in Baltimore, Md.

W. L. Cisler (M '35, F '47), president and director of the Detroit Edison Company, Detroit, Mich., has been installed as first vice-president of the Society of American Military Engineers. He has served on the following AIEE Committees: Power Generation (1935-43, chairman 1940-42), Management (1947-54, chairman 1948-49), and Edison Medal (1956-61).

S. B. Crary (AM '31, F '45), system analysis engineer in the General Electric Company's Electric Utility Engineering Section, Schenectady, N. Y., has received an honorary degree of D.Sc. in engineering from Wayne State University. The degree was conferred at Wayne's College of Engineering honors convocation. Mr. Crary has served on the AIEE Transmission and Distribution Committee (1941-53, chairman 1951-53) and Lamme Medal Committee (1952-55, chairman 1954-55).

G. J. Crowdes (AM '21, F '46, Member for Life) has been elected vice-president of Simplex Wire & Cable Company, Cambridge, Mass. Officers re-elected by the board of directors were **P. R. Morss** (AM '25), vice-president, and **W. N. Eddy** (AM '22, F '40, Member for Life), vice-president. Mr Crowdes, who had been director of engineering since 1958, is now responsible for all engineering activities of the company. He has served on the AIEE Insulated Conductors Committee (1955-60) and General Administration Department (1952-60).

T. M. Dahl (AM '52, M '55) has been named manager of the Chicago, Ill., office of United Engineers & Constructors Inc., Philadelphia, Pa. He was formerly new business representative in the firm's midwest region.

James DeKiep, (M '43, F '54), engineering vice-president of the Electric Machinery Manufacturing Company, Minneapolis, Minn., has been appointed chairman of the American Standards Association's C-50 Committee. Mr. DeKiep will also be the technical advisor on rotating machinery of the International Electrotechnical Commission which will meet November 1960 in New Delhi, India. Mr. DeKiep has served on the AIEE Rotating Machinery Committee (1948-60).

J. J. Dempsey (AM '41), general manager of the Mechatrol Division of Servomechanisms, Inc., Westbury, L. I., N. Y., and vice-president of the parent company, has been named president of the Long Island Electronics Manufacturers' Council.

F. P. Diemer (AM '47) formerly projects manager on the advance planning staff of the Hughes Aircraft Company's laboratories, Culver City, Calif., has become vice-president and director of engineering for the Defense Products Group of Daystrom, Inc.

E. N. Dingley, Jr. (M '56, F '57), a principal engineering scientist in the Scientific Advisory Group of Electronic Communications, Inc., has been elected to the National Administrative Committee of the Institute of Radio Engineers' Professional Group on Military Electronics.

L. P. Duck (AM '44) has been named manager of the Syracuse, N. Y., District of the Western Instruments Division of Daystrom, Inc. He was formerly a senior sales engineer with Weston in Philadelphia, Pa.

W. H. Esselman (AM '39, M '57) of Pittsburgh, Pa., has been appointed to the newly formed 15-member advisory board of the Newark College of Engineering Research Foundation. Dr. Esselman is a member of the Astronuclear Laboratory group of Westinghouse Corporation.

J. F. Fairman (AM '20, F '35, HM '55), senior vice-president, Consolidated Edison Company of New York, has been selected to receive the 1960 National Society of Professional Engineers Award for outstanding service to the engineering profession. The 1960 Award cites Mr. Fairman for his " . . . outstanding performance and originality in utility system design and operation; responsible citizenship in national defense; pioneering leadership in the development of nuclear energy for peaceful purposes; and continued initiative in the advancement of the engineering profession." Formal presentation of the award was made at the society's annual meeting in June in Boston, Mass. During the meeting, **G. S. Brown** (AM '33, F '50) dean of engineering at the Massachusetts Institute of Technology, spoke on engineering curriculum changes. Mr. Fairman has served as the AIEE president (1949), District 3 vice-president (1944-46), and director (1946-49), and as a member of the following AIEE Committees: Executive (1944-47, 1949-52, chairman 1949-50); Planning and Co-ordination (1945-52, chairman 1945-47); and United Engineering Trustees (1957-60). Mr. Brown has served on the AIEE Education Committee (1958-60).

D. C. Fleming (AM '50) has joined Spectrol Electronics Corporation, San Gabriel, Calif., as senior project engineer in charge of the company's reliability and standards program for precision wire-wound potentiometers. Mr. Fleming came to Spectrol after 7 years at the AC Spark Plug Division of General Motors Corporation.

R. W. Fugill (AM '51) has been appointed supervisory engineer, special control and regulator group, Allis-Chalmers Manufacturing Company, Milwaukee, Wis. **E. R. Johnson** (AM '56) has been named supervisory engineer, metalworking and mill control group, of the company. Mr. Fugill was formerly application engineer in the control department. Mr. Johnson joined the company's control department in 1956 as an application engineer.

J. L. Fuller (AM '37, F '59) is the senior partner of John L. Fuller and Associates, a company which went into operation May 1 in Cleveland, Ohio. Mr. Fuller spent 19 years at Reliance Electric and Engineering Company and 5 years as director of engineering at the Marquette Division of Curtiss-Wright.

J. J. Giba (AM '37) has been appointed manager, Tele-Dynamics Division, American Bosch Arma Corporation, Philadelphia, Pa. Mr. Giba had been acting manager of the division since February.

R. W. Gilbert (AM '36) has been named director of corporate research, Daystrom, Inc., West Caldwell, N. J. For the last 2 years, Mr. Gilbert had been vice-president of research and development for Daystrom's Industrial Products Group, Newark, N. J.

C. G. Grimes (AM '33, M '41), formerly director of research, has become vice-president—research of the Electric Storage Battery Company, Philadelphia, Pa.

N. C. Grimshaw (AM '58) has been appointed to transformer development in the Allis-Chalmers Manufacturing Company's Power Equipment Division, Terre Haute, Ind., Works. Mr. Grimshaw recently completed the Allis-Chalmers training course for graduate engineers.

E. A. Guillemin (AM '24, F '51) has been appointed Webster professor of electrical engineering at the Massachusetts Institute of Technology (MIT). A member of the teaching staff at MIT since 1926, he is the seventh to occupy the chair.

N. I. Hall (M '56), vice-president engineering, of Hughes Aircraft Company, Culver City, Calif., has been assigned to product reliability responsibilities of the company.

W. J. Healey (AM '58), a veteran of 45 years in the field of electrical instrumentation, has retired from his position as key account sales engineer in the New York district office of Weston Instruments Division of Daystrom, Inc. Mr. Healey joined Weston in 1929 as an instrument sales engineer in its New York office. Until 1950, he served as key account salesman in the district, handling power companies, public utilities, and governmental units—both federal and city—as well as major electrical and photographic distributors. In 1950, he became district manager for Weston and served in that position until 1958. He plans to continue in sales engineering and consulting.

D. L. Hemmenway (AM '29, M '52) has joined Arthur R. Mogge, Inc., as technical director. Mr. Hemmenway came to the

agency from the magazine *Electric Light and Power*, where he was senior technical director.

W. C. Henderson (AM '51) has been appointed manager, utility sales, and **A. W. Leighton** (AM '58) as manager, industrial sales, Los Angeles, Calif., district, of the Allis-Chalmers Manufacturing Company's Industries Group. Mr. Henderson, who succeeds Mr. Leighton as manager of utility sales, had been a sales representative in the Los Angeles district.

M. P. Hnilicka (M '46) has been promoted to the new post of scientific assistant to the vice-president and director of research for National Research Corporation, Cambridge, Mass. Dr. Hnilicka joined National Research in 1952 and, in 1957, was named a senior engineering associate. He has served on the AIEE Basic Sciences Committee (1959-60).

P. L. Howard (M '50), assistant vice-president of Yardney Electric Corporation, New York, has been elected chairman of the Metropolitan New York Section of the Electrochemical Society.

Hans Jordan (AM '41, M '52) has been promoted to the newly created position of vice-president—engineering counsel of Waste King Corporation, Los Angeles, Calif., and **A. M. Anderson** (AM '54) to the new post of vice-president—appliance engineering. Dr. Jordan was elected vice-president—engineering in 1957. Mr. Anderson formerly headed the engineering program for Hotpoint's laundry department.

J. B. Kelley (AM '43, M '52) has been appointed assistant to the executive vice-president at Burns and Roe, Inc., New York, N. Y. He was formerly project manager and assistant to the director of the Defense and Aeronautical Facilities Division.

F. M. Kinney (AM '50) has joined Good-All Electric Manufacturing Company. He was formerly manager of industrial control sales of the Vickers Electric Products Division of the Sperry-Rand Corporation.

Y. H. Ku (F '45), professor, Moore School of Electrical Engineering, University of Pennsylvania, was awarded a Gold Medal by the Ministry of Education, Republic of China, for his scientific contributions during recent years. He is the author of "Analysis and Control of Nonlinear Systems" and "Electric Energy Conversion." In 1959, he was elected a Fellow of the Academia Sinica. His paper "Theory of Nonlinear Control" was presented before the First International Congress on Automatic Control in Moscow, USSR, in June 1960.

T. J. Kuehn (AM '50) has been appointed manager, sales engineering electronic ceramics, at the Carborundum Company's Latrobe, Pa., plant. He was previously assistant manager, Ceramic Sales.

P. T. Lagrone (M '48) has been named vice-president in charge of the Westinghouse Electric Corporation's Southeastern region, headquartered at Atlanta, Ga. He was formerly assistant regional manager for Westinghouse in the Southeast. In his new position, Mr. Lagrone succeeds **O. O. Rae** (AM '26, M '56), who retired on May 1 after more than 40 years with Westinghouse. Mr. Rae joined the Westinghouse graduate student course at Pittsburgh, Pa., in 1919. Two years later, he was transferred to the Atlanta office where he became electric utilities manager in 1934. He was appointed Southeastern regional manager in 1950 and was elected vice-president in 1954. Mr Rae holds the Westinghouse Order of Merit for distinguished service.

H. D. Langley (AM '51) has been appointed marketing manager—motor control of Federal Pacific Electric Company, Newark, N. J. Mr. Langley was formerly chief engineer of Square D Ltd. of England.

E. N. Lenk (AM '58), assistant superintendent in the Engineer of Manufacture personnel and co-ordination organization at Western Electric Company's Hawthorne (Chicago, Ill.) Works, has been awarded a Sloan Fellowship by the Massachusetts Institute of Technology (MIT). He was one of 44 selected by MIT for a year-long intensive management course, beginning June 1960, which leads to the M.S. degree in industrial management.

J. T. Ludwig (AM '55), until recently a senior research and development engineer with the Minneapolis-Honeywell Regulator Company, has been appointed to the Scientific Advisory Group of Electronic Communications, Inc., as a principal engineering scientist.

H. E. Marmaros (AM '38, M '51) has been appointed resident manager for the new Washington, D. C., offices of Middle West Service Company. He has been associated with the company for 2 years.

L. H. Matthias (AM '39, M '45), vice-president in charge of research, Allen-Bradley Company, Milwaukee, Wis., was cited for outstanding accomplishments in his field at the 12th annual Wisconsin Engineers' Day celebration on May 6 at the University of Wisconsin campus. Mr. Matthias graduated from the university in 1927. Mr. Matthias is the holder of 22 patents in his field, the author of numerous technical articles, and has been active in national engineering professional societies. He has served on the following AIEE Committees: Industrial Control (1946-60, chairman 1955-57); Special Publications (1957-60); and Standards (1958-60).

G. D. McCann, Jr. (AM '38, F '50), founder of Computer Engineering Associates and head of the electrical engineering department and Computer Laboratory at the California Institute of Technology, was recommended by the Board of Directors of the Susquehanna Corporation, Chicago, Ill., for election to the Susquehanna Board.

R. E. Morris (AM '47, M '53) has been appointed manager, Midwest region, Industries Group, Allis-Chalmers Manufacturing Company, with headquarters in St. Louis, Mo. He was formerly manager of the St. Louis district, the position now held by **J. A. Sudduth** (AM '56). Mr. Sudduth had been manager of the company's Grand Rapids, Mich., district, and has been followed in that position by **W. S. Wright** (AM '53). Mr. Wright had been a sales representative in the Grand Rapids district.

E. E. Moyer (M '44, F '51), former director of research at Acme Electric Company, has been named head of research and development at C & D Batteries' Pennsburg, Pa., plant. C & D of Conshohocken, Pa., is a division of the Electric Autolite Company. Mr. Moyer has served on the AIEE Industrial Control Committee (1948-60) and Industry Division Committee (1959-60).

C. E. Muller (AM '58) has been appointed manager, utility sales, of the Allis-Chalmers Manufacturing Company's San Francisco district. He was formerly a sales representative.

E. V. Noe (AM '51), chief, specifications and bids, Pacific Gas and Electric Company, has been elected treasurer of the Engineering Societies Personnel Service—San Francisco Advisory Committee.

K. A. Norton (AM '41, F '56), chief of the Radio Propagation Engineering Division at Boulder, Colo., Laboratories of the National Bureau of Standards, has received the 1960 Harry Diamond Memorial Award of the Institute of Radio Engineers, which is offered to a government employee in the field of radio and electronics. He was cited for " . . . contributions to the understanding of radio wave propagation." Mr. Norton has served on the Television and Aural Broadcasting Systems Committee (1955-60).

Woodman Perine (AM '35, M '47) has become vice-president of Vitro Corporation of America, New York, N. Y., in charge of Vitro's technical services and products group. Mr. Perine was formerly president of the Treco Division of Vitro.

E. S. Reed (AM '52) has been named sales manager of the Rockbestos Wire & Cable Company, a division of the Cerro de Pasco Corporation. Mr. Reed has assumed the responsibility of supervising the sales activities of the main company plant in New Haven, Conn., as well as branch offices in several cities throughout the country and two warehouses in Chicago, Ill., and California.

W. K. Roots (AM '54, M '56) has been appointed chief engineer of Mears Electric Controls, Inc., and Mears Electric Circuit Breakers, Inc., of Portland, Oreg.

F. M. Ryan (AM '19, F '46, Member for Life), former head of the Radio Section of the headquarters organization of the American Telephone and Telegraph Company, has been elected vice-president and director of engineering at Page Communications Engineers, Inc., a subsidiary of Northrup Corporation, Washington, D. C.

A. J. Rynkus (AM '52) of Owego, N. Y., has been appointed technical publications engineer, manager of technical writing,

at the Owego facility of the Federal Systems Division of International Business Machines Corporation (IBM). He had been manager of publications. **W. J. Steen** (AM '40, M '50) has been appointed development engineer, manager of radar engineering, at IBM Owego. Mr. Steen was formerly a staff engineer in systems analysis.

W. A. Schmidt (AM '52) has been appointed manager of operations, Kinetics Corporation, Solana Beach, Calif. He was formerly an assistant design group engineer on the Atlas project at Convair-Astronautics.

L. E. Schooley (AM '44, M '50), director of operations, long lines department, American Telephone and Telegraph Company, New York, N. Y., is the recipient of the Missouri Honor Award for Distinguished Service in Engineering. This award is given by the College of Engineering and the Engineering Foundation of the University of Missouri. Mr. Schooley was honored . . . "in recognition of his successful and outstanding career in the field of telephone communication; his services and engineering contributions to the development of long distance dialing, television, and microwave relay systems; his administration and engineering skill as chief engineer of the Southern Bell Telephone and Telegraph Company, and later as vice-president and general manager of the Indiana Bell Telephone Company."

G. E. Spaulding (AM '54), director of research of the Electric Autolite Company, Toledo, Ohio, will head the new Special Products and Research and Development Division.

J. W. Strong (AM '45) has been appointed a manufacturers representative for the Thomas & Betts Company, Elizabeth, N.J. He will cover the States of Colorado, Wyoming, and Eastern Montana.

T. W. Trice (AM '36 M '49) has been elected vice-president of Electric Operations of the Baltimore Gas and Electric Company, Baltimore, Md. **T. E. Marburger** (AM '38, M '42) was named vice-president of engineering and construction. Mr. Trice was formerly general superintendent of electric operations, and Mr. Marburger previously held the position of general superintendent of electrical engineering and construction.

H. J. West (AM '47, M '55) has been promoted from station electrical engineer to special assistant to the vice-president, engineering, of the Pennsylvania Power & Light Company, Allentown, Pa. In his new position, Mr. West heads up the company's studies and information activities in connection with the development of Delaware River Basin water resources. **Paul Holtz** (AM '54), formerly substation engineer, has succeeded Mr. West as station electrical engineer. Mr. Holtz is in charge of the company's generating stations, substations, relay and control, and research and development for the Electrical Engineering Division. Mr. Holtz has served on the AIEE Switchgear Committee (1954-60).

Fred Wurtzell (AM '48) has been appointed manager-wire and cable market for the Union Carbide Plastics Company, a division of the Union Carbide Corporation, New York, N.Y. He was previously assistant regional manager in the New England Region.

R. A. Yereance (AM '54) has joined the staff of Battelle Memorial Institute's Reliability Engineering Division, Columbus, Ohio. He was formerly with North American Aviation in Los Angeles, Calif., where he was engaged in the evaluation of electronic components.

OBITUARIES

William Charles Bruckman (AM '39), chief engineer, O'Keefe & Merritt Company, Los Angeles, Calif., died recently. He was born March 30, 1910, in Denver, Colo., and graduated from Antioch College in 1932 with the B.S. degree in engineering. Mr Bruckman began his industrial career with Westinghouse Electric Corporation in Mansfield, Ohio, in 1933. He was associated with and responsible for the development of many home laundry appliances in use today. During 1955-57, he was director of engineering at the St. Joseph Division of the Whirlpool Corporation. Since 1957, he had been chief engineer at O'Keefe & Merritt, where he developed a combination washer-dryer, electric built-in and wall-hung ranges, and gas barbecue-broiler.

Craven Hoge Crawford (AM '35, M '45), electrical and radio engineer, General Electric Company, Syracuse, N. Y., died recently. He was born February 28, 1898, in Deweese, Nebr., and graduated in 1925 from the University of Nebraska with the B.S. degree in electrical engineering. Following graduation, he joined General Electric as a student engineer in the testing department. In 1929, he was transferred to the radio engineering department. He was the co-author of a paper, "Silicon Steel in Communication Equipment," which he delivered at the AIEE Winter Meeting in New York in 1936. This paper was published in the December 1935 issue of *Electrical Engineering*. Mr. Crawford came to the Syracuse plant in 1946 and had been associated in engineering standardization work in the field of electronic equipment. He is a member of Sigma Xi and the Standards Engineers Society, and was a registered professional engineer in the State of New York.

Thoman Albert Hopkins (AM '44, M '48), sales promotion manager, Peterson Tractor Company, San Leandro, Calif., died recently. He was born February 29, 1916, in Salt Lake City, Utah, and graduated from the University of Utah with the B.S. degree in electrical engineering in 1937 and the electrical engineering degree in 1946. During 1937-39, he was an engineer-in-training for the Caterpillar Tractor Company. He was advanced to application engineer in the engine department in 1939 and to research engineer in the research department in 1942. Four years later, he became staff engineer in the research department. Mr. Hopkins had been sales manager with the Peterson Tractor Company since 1953. He served on the AIEE Rotating Machinery Committee (1948-49) and Research Committee (1948-50).

Charles Douglas Lindridge (AM '19, M '19, Member for Life), retired engineer, Montclair, N. J., died recently. He was born May 17, 1886, at Hastings, Sussex, England. Mr. Lindridge was employed in the equipment department of the New York Telephone Company in 1906-07. During 1907-17, he was associated with the Providence Telephone Company, Providence, R. I., in succession, as assistant equipment engineer, assistant traffic engineer, and engineer. During World War I, he served in the U.S. Army Signal Corps and in the Office of the Chief Signal Officer, Washington, D. C. In 1919, he was employed by the Western Electric Company. He joined Bell Telephone Laboratories in 1925 and retired in 1951 from his position in the sound research department of Bell Telephone in Murray Hill, N. J.

George Noble (AM '34), standards engineer, Dominion Engineering Works, Ltd., Quebec, Canada, died recently. He was born May 14, 1894, in Northumberland, England. During 1909-14, he was an apprentice engineer with Charlaw & Sacriston Coal Company, Ltd., Durham, England. He was employed as a sales engineer in 1921 by T. W. Cunningham & Company, Ltd., Newcastle-on-Tyne, England. During 1923-30, he was employed as an electrician by the Consolidated Mining and Smelting Company of Canada, Ltd., and its subsidiaries. In 1930, he became electrician-in-charge of the mines in the Mountain Park Collieries, Ltd. He joined the Dominion Engineering Works in 1946, and became standards engineer in 1947. Mr. Noble was a fellow of the Standards Engineers Society, and was active in the Canadian Standards Association and the Society of Automotive Engineers.

Wilfred Van Nest Powelson (AM '00, Member for Life), retired naval officer and public utilities executive, died recently at the age of 87. Mr. Powelson was graduated from the U. S. Naval Academy in 1893 and was sent by the Government to study naval architecture at the University of Glasgow. Assigned to investigate the sinking in 1898 of the battleship Maine in Havana harbor, when 266 lives were lost, Mr. Powelson testified in the court of inquiry that the Maine was blown up by a mine. During the Spanish-American War, he commanded the gun on the St. Paul that sank the torpedo boat Terror near Puerto Rico. Later, Mr. Powelson served as president of the Union Electric Light and Power Company in St. Louis. In 1908, he became a member of Cooper & Powelson of New York, engineers and managers of public utility corporations. He was a lieutenant commander in the Navy during World War II, in which he served as a materials inspector in the New York district. He served as president of the Southern States Power Company in North Carolina, 1924-42.

OF CURRENT INTEREST

THIS IS "VSMF—THE MICROFILM CATALOG FILE" which will save engineers and purchasing agents millions of hours a year by reducing by 90% the amount of time they spend searching for product information. The system was developed by the Technical Services Division of Rogers Publishing Company, Denver, Colo., in co-operation with Recordak Corporation, a subsidiary of Eastman Kodak.

Microfilm Catalog File Cuts Product Searching Time 90%

A NEW SYSTEM, recently announced, will save engineers and purchasing agents millions of man hours per year that they now spend searching for technical information.

Called "VSMF—The Microfilm Catalog File," the unit, a catalog filing system on microfilm, was developed by Technical Services Division of Rogers Publishing Company, Denver, Colo., in collaboration with Recordak Company, a subsidiary of Eastman Kodak.

According to R. H. O'Brien, vice-president and general manager of Technical Services, the first edition of VSMF was produced for the missile/aircraft industry "because of the acute need of that industry for fast and accurate information."

Mr. O'Brien said that other editions will be published later this year for the communications industry (manufacturers of radar, television, data-processing equipment, ground control equipment, etc.), and the electric power and automotive industries.

By 1961, he added, the system will be available for manufacturers of industrial machinery and of instruments, photo equipment, and appliances.

Survey Indicates Need

A recent survey showed that the average engineer spends about 15% of his time—or some 300 hours per year—searching for product and specification data.

"Experience has proven," he said, "that the new VSMF system will reduce this searching time by 90%."

A high-speed easy-to-use facility which stores, retrieves, and permits the rapid reviewing of technical literature, the VSMF unit consists of a microfilm file, reader, and photo-copying device.

It was stated that the system was developed at the request of top engineers in the missile/space industry, and that it is a co-operative effort between the Government's prime contractors, suppliers to the missile/aircraft industry, and Technical Services.

How It Operates

The VSMF system works as follows: the user looks up the item in which he is interested in a copyrighted index which has been cross-referenced for easy use. This refers him to the reel of microfilm on which the information is contained.

The user then inserts the reel into the viewing machine, and by means of a high-speed control switch, can locate the page in which he is interested within 15 seconds. The reading device scans the microfilm file at the rate of 200 pages per second.

A magnified copy of the catalog page appears on a television-like screen that is 13 inches square. By means of a photo-copying device atop the reader, the user can make a picture of the page in 30 seconds which can be taken back to his desk.

The VSMF system also provides the user with the name and address of the nearest sales office of the company which makes the product. To keep the information current, the reels are revised and up-dated every 4 months.

The first edition contains more than 25,000 catalog pages recorded on 22 reels of microfilm; other pages will be added as the system is developed.

VSMF also uses a new development in microfilm techniques: an automatic self-loading magazine which makes the handling of the microfilm unnecessary.

The system is leased to user companies on an annual basis, Mr. O'Brien said, and "costs less than the yearly salary of a file clerk." He said the cost to supplier companies is "far less than the cost of printing and distributing product and specification catalogs." EE

THE VSMF SYSTEM works as follows: the user (1) locates product group in index; (2) removes reel from rack, inserts it at left side of reader, turns on reader; (3) using slow-scan switch, locates reel index, finds page number of desired product; (4) using rapid scanner, locates catalog pages; (5) if required, uses rapid printer, takes picture of desired information (full size).

Offutt Air Force Base Serves as Command Post of SAC

INASMUCH as the United States Strategic Air Command's main function is command and control of an air force which is scattered all over the globe and since that control is at Offutt Air Force Base near Omaha, Nebr., an essential phase of the whole operation is communication between the command post at Offutt and bases throughout the world.

Naturally, because of the necessity of instantly communicating with bases in Great Britain, North Africa, or Spain, not to mention those on the North American continent, the main contact is by voice radio with telephones and teletypewriters also playing important roles. All circuits are monitored 24 hours a day so that communications are maintained with any SAC base; this can be done practically instantaneously. Not only can radio communication be established with any SAC base in the world, but also with any SAC tactical aircraft no matter where it may be flying.

Wullenweber Antenna

Of course, reliability and speed of communications is the watchword and it has been determined that single-sideband voice radio on 11, 15, and 20 mc is the optimum. To this end, a transmitting site has been set up at Elkhorn, a remote point near Offutt AFB, where transmitting antennas of the most efficient types cover the landscape. One of the more interesting is a Wullenweber installation, consisting of two concentric circles of masts, the outer ones being 172 feet tall and the reflecting inner ring being 160 feet. The diameter of the outer circle is 260 feet. This is an electronic steerable antenna with beaming of transmission possible every 20 degrees around the circumference.

The optimum frequency of transmission to be employed for a given distance and time of day is found by means of a radar-like device. The distance is dialed into the instrument and shown on 500-mile-range circles on a PPI indicator, on which screen is an outline world map, by a bright marker. On a horizontal-line cathode-ray tube type of display, a long blip indicates the frequency for the proposed transmission.

Underground Center

The command post itself extends 45 feet below ground level. Facilities there include a communications center, a global weather center, connections to the world-wide radio communication system, a special long-distance telephone system connecting the SAC Headquarters to each SAC airbase. In case of enemy attack, this command post could be sealed off and would become self-sustaining. It has its own air-conditioning system, an independent water and food supply, emergency electric system, as well as complete teletypewriter and voice transmission systems. An emergency antenna, ordinarily concealed, could be raised 135 feet above the roof so that communications would be uninterrupted.

Four live color television cameras and a complete closed-circuit television system are installed in the operations center and control room. Instantaneous briefings can be conducted by the closed-circuit television system, so that key staff officers need not go to several display rooms for information on which their decisions may be based. Cameras are installed in the operations map room, the intelligence air room, and the global weather center. Receivers are located in 17 key offices.

In the map room, information concerning the global air force of bombers, tankers, and missiles, posted on 2-story-high panels, is telecast daily. These charts include displays of how the air forces are deployed, status of aircraft and missiles, training exercises, communication status, and the weather. EE

USAF Photo

A BRACE of SAC Control Center Air Policemen, wearing sidearms and their famous berets, guard the corridor at the main entrance to the SAC Underground Command Post. Maximum security measures protect this area.

BURIED far below the earth is SAC's single most important building—the 3-story command post built of reinforced concrete and containing this 140-foot-long operations control room (*above, left*). Along one wall of the 39-foot-wide and 21-foot-high room are floor-to-ceiling panels containing maps, charts, and other data required in SAC's daily operations or, should an emergency arise, to carry out emergency war plans. The huge panels, suspended at the top and mounted on wheels at the bottom, can be moved the length of the room as required. *Above, right:* This 172-foot Wullenweber antenna, measuring 500 feet across the center, plus a myriad of other single-sideband transmitter and receiver antennas, has increased the power of SAC's ground-to-air communications to 45,000-watt capacity. This antenna at Elkhorn, Nebr., is one of only three in the Western World.

USAF Photos

Van Allen Radiation Belt on the Planet Jupiter

Radio astronomers of the California Institute of Technology announced recently that they have established almost conclusively the existence of a Van Allen radiation belt on the planet Jupiter. The belt is about 200,000 miles above the surface of the planet, which itself is about 85,000 miles in diameter.

The discovery was made at the new Caltech Radio Observatory in Owens Valley. The research is supported by the Office of Naval Research, which financed construction of the observatory at a cost exceeding $1 million.

The finding is due to the fact that high-speed electrons trapped in Jupiter's magnetic field emit radio waves as they spin back and forth along the lines of magnetic force by what is known as the synchrotron mechanism, explained Prof. John Bolton, observatory director.

Unexpectedly high radio emission at a wavelength of 10 centimeters (3.9 inches) was first detected by scientists at the Naval Research Laboratory in Washington, D.C., 2 years ago. Their findings were confirmed last year at other short wavelengths both at Caltech and the National Radio Observatory and the synchrotron mechanism from a Van Allen type belt was immediately suggested as a possible origin.

The only hope of proof of this mechanism lay in detecting linear polarization of the radio emission and the region of emission. Like light waves, radio waves may be polarized—i.e., as electrons spiral around lines of magnetic force, they emit radio waves that are much stronger paralleling their lines of motion.

In one experiment, such polarization has been detected, Prof. Bolton said, indicating the presence of a magnetic field on Jupiter with its axis almost parallel to the planet's rotation axis—as is the earth's magnetic field.

In a second experiment, the diameter of the source of radiation has been measured. This shows that in a direction parallel to the planet's equator, the radio source is between 400,000 and 500,000 miles across.

Both measurements were possible only because of the unique instruments at the Caltech Observatory. The principal telescope consists of two 90-foot diameter steerable mirrors mounted on a railroad one third of a mile long. For certain observations, the two mirrors may be used to simulate the effect of a single mirror equal in diameter to the distance between them. The individual mirrors are the largest of their type in the United States and second only in the world to the 250-foot mirror at Jodrell Bank in England.

The observations of Jupiter were made by Venkataraman Radhakrishnan of India and Dr. J. A. Roberts of Australia, who currently are working at the observatory.

Calculations show the radio energy from the Jupiter belt is 100 trillion times that expected from the earth's Van Allen belt. The earth's belt already is considered to be a hazard to space travel and it is quite obvious that the Jupiter belt would be a much more serious hazard, Prof. Bolton pointed out.

The planets Mercury, Mars, Venus, and Saturn have been examined for similar radiation but none has been found on such a scale as Jupiter's.

THESE TWIN 90-foot reflectors at the Caltech Radio Observatory were used in measurements which led to the almost conclusive discovery of the existence of a Van Allen radiation belt on the planet Jupiter. The steerable mirrors are mounted on a railroad one third of a mile long. For certain observations the two may be used to simulate the effect of a single mirror equal in diameter to the distance between them. The individual mirrors are the largest of their type in the United States and second only in the world to the 250-foot mirror at Jodrell Bank in England.

Gallium Phosphide Used for Studying Semiconductors

Scientists at Bell Telephone Laboratories are developing methods of growing single crystals of a transparent semiconductor, gallium phosphide, and studying its properties. These studies will help in the basic understanding of high energy gap semiconductors, part of a field of research which has interested Bell Laboratories since well before its invention of the transistor in 1948. The material is transparent, making it possible to observe visually the differences which take place under varying conditions of doping and electron density.

Gallium phosphide belongs to the family of semiconductors referred to as "III-V compounds," which are composed of elements taken from each of the III and V groups of the periodic table. Knowledge gained in studying it should be applicable to other members of this group, some of which are already known to exhibit interesting properties. These include gallium arsenide and indium antimonide, which have shown promise in devices such as point contact and Esaki diodes. Many other III-V compounds have yet to be synthesized.

C. J. Frosch and M. Gershenzon of Bell Laboratories reported recently on the preparation and properties of gallium phosphide to the meeting of the Electrochemical Society at Chicago, Ill. Their paper was followed by one by Dr. Gershenzon and R. M. Mikulyak on the preparation and characterization of p-n junctions in gallium phosphide.

Although the semiconducting properties of gallium phosphide were first reported in 1954 by G. G. Folberth and F. Oswald in Germany, pure samples have been very difficult to prepare. One of the main problems is that it decomposes at temperatures near its melting point unless it is held under high pressures of gaseous phosphorous. The work reported recently has been aimed at producing single crystals of gallium phosphide by the floating zone melting technique. Special equipment had to be built to withstand the high pressure phosphorous atmosphere.

In the experimental equipment, an ingot of gallium phosphide is enclosed in a sealed quartz tube which is encased within a steel pressure chamber equipped with viewing ports. At the temperatures and pressure involved—1,450 to 1,500 C (2,640 to 2,730 F) and 10 to 50 atmospheres pressure—the walls of the quartz tube fog over, making observation of the molten zone difficult. This can be overcome to a large extent by heating the walls of the apparatus to above 950 C. Single crystals about ¾ inch long by ¼

C. J. Frosch (left) watches the molten zone in an ingot of gallium phosphide which is being float-zone melted under pressure. M. Gershenzon watches through opposite observation port, while Robert Mikulyak adjusts current through coils used for heating the ingot. Experimental work on growth and purification of single crystals of gallium phosphide, a III-V compound semiconductor, is aimed at a general understanding of semiconductors and junctions. Semiconductor diodes have been prepared from this material which will operate continuously at over 550 C (930 F).

inch square have been obtained by Frosch and Gershenzon.

Small single crystals have also been grown by vapor reaction methods by Gershenzon and Mikulyak. Their method, which was described recently at the American Chemical Society, involves a reaction of gallium suboxide (Ga_2O) and phosphorous in the vapor phase. These crystals show a whisker form or habit. They are usually n-type semiconductors, although they can be doped p-type. They exhibit free carrier concentration of 10^{13} to 10^{14} per cc, as calculated from resistivity measurements.

Diffused and alloyed type diodes have been produced by Gershenzon and Mikulyak. Sample diodes have shown breakdown voltages as high as 35 volts, and rectification ratios up to 3×10^6. They perform well up to 500 C. The diodes exhibit two interesting anomalies. They have an almost intrinsic layer which gives rise to a current-limiting series resistance, and they possess recombination-generation centers within the junction transition region. These produce variations in the forward and reverse current characteristics, and time lags in the establishment of steady-state conditions. EE

Electronic Stand-In For Human Voice Used for Testing

The development of an electronic "stand-in" for the human voice in the testing of communications equipment was announced recently by the U.S. Army.

The dual purpose instrument, the Automatic Articulation Tester, is used in development of radio equipment which must deliver messages sharply and clearly through noise, natural radio interference, and enemy jamming efforts. In addition, the articulation tester is valuable for measuring the effectiveness of devices and tactics for jamming an enemy's radio channels.

In use, the new device records a single person's voice on special magnetic drums to provide a speech pattern, or standard. The speech standard is a valuable tool in the equipment development. The voice recording can be composed of the phonetic alphabet and numerals or an actual message.

A listener is placed in a room next door or thousands of miles away or in a tank surrounded by battle noises. The recorded material is fed to him over a communications system into which the equipment being tested is connected. The listener uses a remote console with buttons marked to represent the recorded words.

As the tests get underway, he presses the button which matches the word he thinks he hears. This process may be repeated hundreds of times. The machine makes its own random choice of word sequence in order to prevent the listener from memorizing the material.

At the end of the test, the score of words understood correctly is automatically computed and printed. A high mark of comprehension is the aim if radio equipment or antijamming devices are under test, a low score if the object is to improve jamming methods.

The test equipment provides numerous refinements. For example, each word may be repeated several times and the time interval between words varied.

The ability of the listener to comprehend and follow a map route as prescribed by the articulator also can be tested. Provision also is made to use a number of listeners simultaneously.

The Automatic Articulation Tester was developed for the U.S. Army Signal Research and Development Laboratory by Auerbach Electronics Corporation of Narberth, Pa., subcontractor to American Electronics Laboratories, Philadelphia. R. H. Sugarman, a Signal Laboratory engineer, heads the project. EE

Future Meetings of Other Societies

Metallurgical Society of AIME, Conference on Response of Metals to High Velocity Deformation, July 11-12, Stanley Hotel, Estes Park, Colo. AIME, 29 W. 39th St., New York 18, N. Y.

American Astronautical Society, Western National Meeting, Aug. 8-11, Olympic Hotel, Seattle, Wash.

International Electronic Circuit Packaging Symposium, Aug. 18-19, cosponsored by the University of Colorado and *Electrical Design News*, at the University campus, Boulder, Colo.

Symposium on Thermonuclear Plasma Physics, Aug. 22-26, Gatlinburg, Tenn. sponsored by Oak Ridge National Laboratory and Oak Ridge Institute of Nuclear Studies in co-operation with the AEC. University Relations Division, ORINS, P.O. Box 117, Oak Ridge, Tenn.

IRE-WEMA, Western Electronic Show and Convention, Aug. 23-26, Memorial Sports Arena, Los Angeles, Calif. R. G. Leitner, WESCON Business Office, 1435 La Cienga Blvd., Los Angeles.

The Combustion Institute, 8th International Symposium on Combustion, Aug. 28-Sept. 2, California Institute of Technology, Pasadena, Calif.

Machine Tool Exposition, Sept. 6-16, International Amphitheatre, Chicago, Ill. National Machine Tool Builders' Association, 2139 Wisconsin Ave., N. W. Washington 7, D. C.

EIA, 2nd Conference on Value Engineering, Sept. 7-8, Disneyland Hotel, Anaheim, Calif. Electronic Industries Association, Engineering Department, 11 W. 42 St., New York 36, N. Y.

4th Annual Joint Military-Industrial Electronic Test Equipment Symposium, Sept. 14-15, Chicago, Ill., sponsored by the Office of the Director of Defense Research and Engineering and the Department of the Army Signal Corps. S. I. Cohn, Armour Research Foundation, 10 W. 35 St., Chicago.

ISA, 3rd Instrument-Automation Conference and Exhibit of 1960 and ISA's 15th Annual Meeting, Coliseum, New York, N. Y. Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

Overseas

International Electrotechnical Commission, IEC/TC 23 (Electrical Accessories), Brussels, Belgium, July 13-16. ASA, 70 E. 45 St., New York 17, N. Y.

IEE, 3rd International Conference on Medical Electronics, July 21-27, Olympia, London, England. The Institution of Electrical Engineers, Savoy Place, London W.C.2.

UPADI, 7th Convention of the Pan American Federation of Engineering Societies, Sept. 12-16, Buenos Aires, Argentina, G. A. Hathaway, Engineers Joint Council, 29 W. 39th St., New York 18, N.Y.

5th International Instruments & Measurements Conference, Sept. 13-15, Stockholm, Sweden. Helge von Koch, Kungliga Tekniska Högskolan, Stockholm 70, Sweden.

8th Session of United Nations Scientific Committee on Effects of Atomic Radiation, Sept. 19-30, Geneva, Switzerland. United Nations Press Services, Office of Public Information, United Nations, New York, N.Y.

International Conference on Physics of Electrostatic Forces, Sept. 27-Oct. 1, Grenoble, France, Université de Grenoble, Institut Fourier, Place du Doyen-Gasse.

Industrial Latin American Partnership Exhibition, April 1960-Oct. 1961, Parque Ibirapuera, São Paulo, Brazil, E. I. Neville, ILAPE Representative, 60 E. 42 St., New York 17, N. Y.

PROJECT BUTTERFLY: What looks like an automobile transport *(top)* is actually a model of the latest concept in mobile long-range radar design for the military services. The design incorporates long-range detection capabilities with full maneuverability previously not available in equipment of this kind. The large 20- by 43-foot antenna can be unfolded and set up within 15 minutes with a minimum of skilled personnel, in keeping with the high mobility requirements of the military services.

Project Butterfly Mobile Radar System

A new concept in mobile long-range radar design has been announced by the General Electric Company (GE), according to J. J. Farrell, general manager of the company's Heavy Military Electronics Department.

"The new mobile high-power radar concept incorporates long-range detection capabilities with full maneuverability and mechanical ease of operation previously not available in equipment of this kind," Mr. Farrell said.

"Modern warfare requires a highly mobile, tactically flexible, self-contained equipment and we feel that the new concept incorporated in this radar design will fill these military needs."

With engineering emphasis placed on high mobility and a retractable folding antenna structure, the radar system has been appropriately designated "Project Butterfly," although the concept can be applied to any high-power radar currently under development.

This unique folding antenna was designed by GE and the McKiernan-Terry Corporation, Dover, N. J. It is believed to be the first such design offering a practical solution to the mobility problems associated with large, high-gain antennas of this type.

One of the two trailer units in which the Butterfly mobile radar is packaged contains display and power generating equipment. Transmitting and receiving portions of the radar system are housed in a wheel-mounted antenna assembly. Both trailer units can be transported in one C-124 aircraft, or individually towed by standard military trucks.

A further new concept in radar design permits either automatic or manual erection and retraction of the 20- by 43-foot folding antenna. It can be erected by a 5-man crew in 15 minutes with a minimum complement of skilled personnel required to establish and maintain operation.

The 18,000-pound trailer unit containing the electronics section of the radar includes its own lighting, heat, and air conditioning for all-weather operation. A built-in gasoline or diesel generator provides the primary power source for the entire system.

To cope with the possible threat of hurricanes, the Butterfly antenna can be quickly retracted in wind velocities up to 70 mph. In its retracted position, it will withstand winds in excess of 100 mph.

Project Butterfly employs an improved adaptation of a single-channel *AN/FPS-33* acquisition radar, selected for its reliability, advanced circuitry, and tactical flexibility. Over 250 radars of this *AN/FPS-33* type have already been built by the Heavy Military Electronics Department for U.S. Army, Navy, and Air Force applications. **EE**

Midwest Program on Airborne Television Instruction

Some 18 areas in six midwestern states—each with a major college or university as its hub—have been designated as a communications network for the new Midwest Program on Airborne Television Instruction.

MPATI, as it is called, plans to beam instructional telecasts from an aircraft to schools in the six states starting in February 1961. The $7 million project is supported by the Ford Foundation and contributions of private industry.

MPATI has indicated that it will administer the program through 18 area committees blanketing the multistate telecast region. Staffed by an area co-ordinator, the area committees will consist of school and university administrators, educational television representatives, and lay leaders in civic, professional, and other groups in the area.

Each committee will provide liaison between MPATI and surrounding schools and colleges interested in participating in the airborne program.

The area committees will be based at midwestern colleges and universities that traditionally have served their respective geographic areas as resources to the schools, teachers, and administrators of educational systems in the area.

The 18 colleges and universities that have agreed to work with MPATI as "resource institutions" in this capacity are:

Illinois: Northern Illinois University, Northwestern University, and University of Illinois.

Indiana: Ball State Teachers College, Butler University, Indiana State Teachers College, and Indiana University, Notre Dame University, and Purdue University.

Kentucky: University of Kentucky and University of Louisville.

Michigan: Michigan State University, Wayne State University, and Western Michigan University.

Ohio: Bowling Green State University, Miami University, and Ohio State University.

Wisconsin: University of Wisconsin at Milwaukee.

Two members of each area committee also will serve on a Regional Advisory Council to help co-ordinate the entire 6-state program.

Workshops for classroom teachers and school administrators interested in the program have been scheduled during the Summer of 1960 at each of the 18 Resource Institutions plus De Paul University in Chicago.

The program's schedule of operations calls for "demonstration" telecasts from the aircraft to start in February 1961, and continue until June of that year. A full academic year of televised instruction will commence the following September and continue until June 1962.

A tentative schedule of courses that will be beamed to the schools within the 150- to 200-mile radius of the airborne transmitters has been planned. Ranging from elementary level through college, the courses include such topics as foreign languages, science, arithmetic, music, social studies, art, the humanities, and international relations.

The courses will be prepared at Purdue University in a summer-long workshop for selected television teachers and related specialists. They will then be recorded on video tape at designated educational television stations.

Dr. S. M. Brownell, Detroit, Mich. superintendent of schools and former U. S. Commissioner of Education, is chairman of the program's governing council.

A total of 40,000 copies of a brochure describing the program have been printed and are being distributed to educational personnel and news media throughout the 6-state region and nationally. **EE**

Arc Jet Space Engine

Enough thrust to keep a communications satellite on station or to shift orbital altitude was produced continuously during a recent 47-hour run of an Avco arc jet

operating as a space propulsion unit. This experimental space engine operated in a near vacuum for 47 hours, using helium as a working fluid. It produced nearly ¾ pound of thrust at specific impulse of 1,000 seconds with a power input of about 30 kw. The total velocity increase that would have been imparted to a 1,000-pound orbiting space vehicle was calculated to be about 4,000 feet per second. Results of the test were revealed recently by J. R. Kerr, president of Avco's Research and Advanced Development Division, Wilmington, Mass.

For the recent tests, a small arc jet was mounted horizontally on a thrust stand in a vacuum chamber. The chamber was equipped with viewing ports and connected to a vacuum pump. This permitted continuous operation and viewing of the arc jet at an exhaust pressure of approximately 10 mm of mercury corresponding to a simulated altitude of 95,000 feet. At this altitude, only about 1% of the atmosphere remains.

"The results of this test indicate that a reliable long-duration 1-pound-thrust thermal arc engine can be made, and soon," Mr. Kerr declared.

A complete propulsion system would consist of such a thrust device, an electric power supply, and a tank of liquid hydrogen. A propulsion system of this sort lifted into satellite orbit by high-thrust short-duration chemical rockets would have a variety of possible applications.

Although the thrust is small by chemical rocket standards, the arc jet engine may operate continuously for hours or days. This small thrust would impart a continuous "push" on a satellite balanced in orbit around the earth. Although the acceleration would be very small, perhaps a thousandth of a "g," the continuous application of this thrust would result in steady acceleration and eventual very high speeds. Operation for a few minutes at a time might be sufficient to make corrective changes to the attitude or position of communications satellites. The arc jet engine might be operated for a few hours to shift the altitude of the orbit nearer or farther from the earth. Hundreds of hours operation might carry the satellite from low-altitude earth orbit to around the moon in constantly expanding spiral.

The recent 47-hour test is part of a current program to explore problems of a long-duration run, such as electrode erosion and cooling of the nozzle under conditions of space environment. Reliability of components and simplicity of the system are the primary goals.

Avco's approach was to scale down larger arc jets developed for ICBM reentry simulation. The small arc jet used was a modified version of the firm's commercial Model PG-030. This unit is used for flame spray coating with metals and ceramics and for various research purposes wherein 12,000 F flame temperatures are desired.

The current testing program has been supported by the U. S. Air Force Ballistic Missile Division, Air Research and Development Command, as part of investigations in connection with advanced military systems. EE

Space Medical Data System Passes U.S. Air Force Tests

A system designed to give continuous physiological information on pilots in jets or other aircraft as well as radio this information back to earth in numerical form, has been successfully tested at the Air Force Missile Development Center (AFMDC), Holloman AFB, N.M., by AFMDC's Aeromedical Field Laboratory.

Developed for the Air Force by Gulton Industries, Inc., Metuchen, N.J., the system, known as a Physiological Data Acquisition System, is being used to monitor and telemeter 13 different bodily activities of pilots in various types of aircraft.

A continual study of seven different body temperatures, electrocardiograph, heart rate, breathing rate, breathing flow, blood pressure, and galvanic skin response (a measurement of psychological response) are measured by the system at a rate of 120 readings per second. This information is fed into an analog-to-digital converter which translates the readings into numbers, and telemeters this information to a ground station on earth with a time lapse of only eight one-thousandths of a second.

Officials at the Aeromedical Field Laboratory stated that the apparatus had been successfully tested on several different occasions using scientists in aircraft as "test subjects."

The ground station for the system, also developed by Gulton Industries, displays this information numerically on a series of read-out counters, as well as permanently storing the medical data on charts and tape recorders. EE

Near-Perfect Light Amplifier Is Developed by Scientists

A small electronic tube, developed by scientists at the Westinghouse research laboratories, reaches the near ultimate in the ability to amplify ordinary light. The tube, known as the Astracon, is so sensitive that it makes visible a single electron, released at the tube's input by an individual photon—the smallest unit quantity of light that exists.

The electronic development was described by Dr. J. W. Coltman, manager of the electronics and nuclear physics department of the Westinghouse research laboratories in Pittsburgh, Pa.

The Astracon tube operates upon a unique amplifying principle discovered at the Westinghouse research laboratories 5 years ago. The image of an object, so dim that it is invisible to the naked eye, is focused by lenses onto a light-sensitive screen, called a photosurface, at the input end of the tube. The individual particles of light, or photons, arriving from the scene strike the surface and eject electrons from it.

Each ejected electron is then accelerated forward by 2,000 volts and strikes head-on into a thin 2-layer film, only a few millionths of an inch thick. The front surface of the film is aluminum; on its back surface is deposited a slightly thicker layer of an insulating material. When a high-speed electron crashes into the film, it penetrates into the insulator and releases four or five additional electrons. These are accelerated into a second film, or dynode, where the electron multiplication is repeated.

By using five such steps, a single electron is multiplied into about 3,000. These are given a final 20,000-volt boost and are aimed into a thin layer of fluorescent material at the output end of the tube. Here they release 20,000 or more photons of visible light. Thus, if the light striking the input photosurface is in the form of a dim, invisible image, the Astracon exactly reproduces that image on its output, only thousands of times brighter.

"The Astracon achieves the ultimate in amplification," Dr. Coltman declared, "for now we can see individual electrons, released at the tube's input. Each electron shows up as a separate flash of light. The only way we could increase the As-

AN engineer checks out the Avco arc jet space engine before it is placed in a vacuum chamber for a 2-day continuous run in a simulated space flight test. This experimental engine using helium as a working fluid is a prototype of engines being developed for space satellites once they have been placed in orbit. Such engines would provide power to change altitude or position of the satellite.

tracon's remarkable sensitivity is to increase the probability that an incident photon will release an electron from the input photosurface.

"This remarkable ability to record photons makes the Astracon useful in many fields of research. In astronomy it will increase the effective size, or light gathering ability, of the largest telescopes. In nuclear physics it will, for the first time, permit the viewing of the tracks of high-energy cosmic rays and other particles. Until now there has been no practical method for observing these particles as they flash through solid crystals with a feeble glow." EE

Isolated-Phase Bus To Pacific Gas and Electric

The first shipment of General Electric's new isolated-phase bus has been made to Pacific Gas and Electric for use in that utility's Pittsburgh (Pa.) Station.

Designed to reduce losses produced by circulating currents, the new bus utilizes a recently developed method of shielding. By connecting together the ends of the 3-phase bus enclosures, the external flux is reduced by as much as 90% over that existing in standard isolated-phase bus.

Furnished to Pacific Gas and Electric as a self-cooled pressurized unit, the bus is also available with forced-cooling or for 105 F high-temperature operation. EE

Reference System for Titan Unveiled

Details of the guidance reference system that provides a mast of the "electronic brainwork" for the first 2 minutes of flight of the U.S. Air Force's Titan intercontinental ballistic missile have been disclosed by the Aeronautical Division of Minneapolis-Honeywell Regulator Company.

The guidance reference system was developed by Honeywell under contract to Martin-Denver, prime contractor for design and fabrication of the airframe assembly and testing of the mammouth Titan.

The Titan reference system is an advanced version of the "strap-down" concept in which gyroscopes are fastened rigidly to the frame of the missile and react according to preset time signals and external guidance commands.

The system consists of three hermetically sealed integrating gyroscopes, a missile attitude programmer, and an electronically controlled timer. The function of the system is to provide roll-and-pitch programming and 3-axis reference for the guidance and control of the missile.

The system supplies command signals to the autopilot to guide the missile on a prechosen path from the time of launch until the missile's radio guidance system takes over.

When the Titan's 80,000-pound-thrust second stage fires in space, a guidance system directs it to the start of its ballistic trajectory. During this second-stage flight, the reference system senses deviations in the Titan's attitude and provides corrective signals to the control system.

The system is cylindrical in shape—approximately 12 inches in diameter and 15 inches high—and weighs only 45 pounds. The entire package is transistorized and designed to withstand rugged environmental requirements.

As a protection against high-altitude phenomena, the unit is pressure sealed. In early models of the package, the exterior was gold plated to provide high reflectivity as a protection against severe temperature increases.

Gyros used in the system are Honeywell *HIG-4S*, selected for their small size and high degree of accuracy under conditions of shock and vibration. The timer, which has two crystals as the primary time-measuring elements, was developed for Honeywell by Texas Instruments, Inc.

It was stated that the Titan reference system is similar in concept to the highly successful Honeywell-developed Vanguard guidance reference system which was responsible for placing a satellite in an orbit believed to be the most accurate yet achieved. The Vanguard guidance reference system was the first application of three single-axis integrating rate gyros "strapped down" in a missile to provide a space reference system. EE

GUIDANCE Reference system for Titan missile is shown in an evaluation fixture. System is an advanced version of the "strap-down" concept in which gyroscopes are fastened rigidly to the frame of the missile and react according to preset time signals and external guidance commands. Shown without its gold-plated cover, the Titan system consists of three hermetic integrating gyroscopes, a pitch-and-roll programmer, and an electronically controlled timer (covered drum-like section).

Underwater "Eyes" Developed for Navy Divers

Economical new sonar equipment, which is powered by standard flashlight batteries, has been jointly designed by Stromberg-Carlson-San Diego and the U.S. Navy Electronics Laboratory for use by frogmen to give them "eyes" underwater.

Stromberg-Carlson, with headquarters in Rochester, N. Y., is a division of General Dynamics Corporation.

W. G. Alexander, general manager of the San Diego facility, described the diver-held object locator as a lightweight, portable, completely transistorized sonar system used to detect submersed objects.

Official U.S. Navy Photograph

NAVY frogman tests new sonar equipment developed to locate underwater objects. The lightweight, portable, diver-held sonar system is economically powered by standard flashlight batteries. Ear phones provide the diver with audio information on objects detected by the searching sonar beam.

The 20-pound sphere, slightly larger than a basketball, has an aluminum casing and is 1 cubic foot in volume. Grips at the side are held by the diver, permitting easy maneuverability and control.

Earphones provide the user with audio information on objects detected by the searching sonar beam.

The device is particularly valuable to divers and underwater demolition teams operating in dark or murky waters where visibility is zero.

Designated *AN/PQS-1*, the equipment is powered by standard flashlight batteries. This eliminates the problem of supplying expensive, specially built batteries used in similar existing devices, according to Mr. Alexander. He said a savings of over 90% in battery replacement cost will be realized.

As another feature, longer battery life of up to 40 hours is obtained with the new detector since little power is required by its transistorized circuitry. EE

◄ H. L. HOFFMAN, president of Hoffman Electronics Corporation, demonstrates the solar-powered "safety satellite" transmitter for the new emergency calling system now available for installation along congested or remote traffic areas. By pressing a button —for police, ambulance, fire truck, or service truck—a motorist can automatically transmit a 1½-second coded radio message summoning help.

► THE emergency calling system's narrow-band FM receiver, which gives visual as well as printed readout of decoded messages from highway transmitters, pinpoints the location of the distressed motorist, and tells what kind of service is needed. Here, the call is for police assistance in the inbound lane of the Hollywood freeway at a point 2½ miles from the Los Angeles freeway interchange.

Emergency Calling System for Highways Is Developed

Space-age technology has made possible the first practical emergency calling system for highways, it was revealed recently by Hoffman Electronics Corporation, as it unveiled the "safety satellite," a miniature transmitter that uses sunlight as its power source—just as do United States satellites now in orbit.

The "safety satellite" is the basic unit in Hoffman's newly developed emergency calling system designed specifically to offer a means of communication for motorists stranded on freeways, turnpikes, and other superhighways.

"The need for an efficient, economical system such as this has long existed," said H. L. Hoffman, president of the Los Angeles, Calif., electronics firm.

"Until now, the need for external power has been a major problem. The installation of overhead or buried power lines is very costly and, in many cases, impossible," he explained.

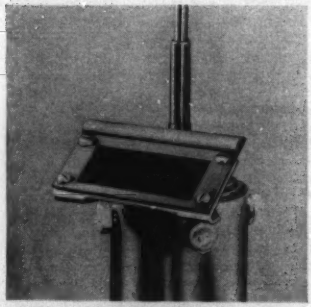
"The 'safety satellite,' inspired by our success with solar energy converters for this country's space program, solves this problem by using sunlight as the entire power source."

The transmitting device is powered by nickel cadmium batteries that are recharged by solar energy. Five tiny silicon solar cells draw enough energy from the sun to keep recharging the batteries so that they never need replacing—even in areas where there is no sunlight for extended periods.

The emergency-call transmitter is housed in a metal box, about 1 cubic foot in size, that can be mounted on a pole or lamp post at convenient locations along a highway. It has a power output of 1 watt which will give reliable communications over a line-of-sight distance of 18 miles.

To operate the transmitter, a motorist simply presses one of four buttons on the transmitter panel: one each for fire, ambulance, police, and service truck.

The message is transmitted by code in 1¼ seconds, and the transmitting unit is then automatically turned off; however, the motorist can repeat the call or make a new call for any of the other three agencies listed.



THE radio transmitter draws its power from nickel cadmium batteries that are recharged by these five tiny silicon solar cells mounted on the transmitter's antenna. Similar to those used on orbiting United States satellites, the solar cells convert sunlight into electricity so transmitter needs no external power lines.

The coded message from the transmitter is picked up at a central point, such as police headquarters, by an FM receiver which feeds into a solid-state digital decoder. This displays the message visually and also provides a printed record.

The message received indicates the type of service desired by the stranded motorist and the exact location of the transmitter originating the message.

The battery pack inside the transmitter is designed to power 150 transmissions without recharging. The current required for one transmission is replenished by 5 minutes of sunlight on the solar cells, which are mounted on a 20-foot antenna atop each transmitter.

Many transmitters can be monitored by one receiver. The entire Los Angeles freeway system, for example, could be covered by 3,000 transmitters and three receiver installations. With this coverage, transmitters could be placed every quarter-mile along each side of the freeways.

Even greater concentration might be used on bridges or other highly congested areas.

The new emergency calling system is expected to have many applications in addition to its use on highways. Resort areas and national parks have long indicated a need for such equipment. The units could be installed on beaches and along trails to insure speedy help in emergencies. **EE**

750-Kv Test Line Project Announced

A project to construct and operate a 750-kv test transmission line at Apple Grove, W. Va., has been announced jointly by American Electric Power Service Corporation and Westinghouse Electric Corporation. Objective of the project is to gain information and experience which will help determine both the technical and economic feasibilities of transmitting large blocks of power at voltages up to 750 kv.

The new extra-high-voltage test project will provide a continuation of the investigations begun by the two companies at Brilliant, Ohio, in 1946 when they built and operated the 500-kv Tidd test line.

Other companies that are participating in the project and the equipment or materials which they are supplying include: Kaiser Aluminum & Chemical Corporation—conductor; Lapp Insulator Company, Inc., and Ohio Brass Company—insulators and hardware; Thomas & Betts Company, Inc.—connectors; and the American Bridge Division of United States Steel Corporation—towers.

Work on the project will start immediately with first tests scheduled for late 1960 or early 1961. The tests will continue for 3 to 5 years.

Based on experience gained on the 500-kv Tidd and Leadville (Colo.) test projects, several innovations in testing techniques will be made in the Apple Grove project.

Three test lines will be built at Apple Grove, each using a different conductor configuration. The lines will be energized simultaneously to measure radio-influence voltages and corona losses, permitting a comparison of test results under identical atmospheric conditions.

In addition, all conductors on all three test lines will continuously carry heating current to simulate actual operating conditions. Test results will be processed through automatic data-logging computers and recording instruments.

Apple Grove is on the Ohio River about 25 miles north of Huntington, W. Va., on the system of Applachian Power Company, one of the American Electric Power operating companies. EE

Voltage Regulator for Distribution Transformers

A new self-contained automatic voltage regulator called UNOREG, for use on the low-voltage side of over 400 standard distribution transformers, has been developed by the Westinghouse Electric Corporation, Pittsburgh, Pa. Rated at 1¼ kva, the new device will handle distribution transformer sizes up to and including 25 kva. In a few months, a 2½-kva model will be available for use with transformers up through 50 kva.

A compact, lightweight design for convenient pole mounting, UNOREG provides ±5% regulation of 120/240-volt secondary lines. The new universal voltage regulator offers flexibility of application and economy of equipment. UNOREG can be applied to a distribution transformer at a cost of only $150 plus installation costs.

Development of UNOREG started after computer studies of literally thousands of hypothetical systems led to two principal conclusions:

1. The most economical system is the one that is built to operate without re-regulation.

2. However, when re-regulation is necessary, it can be obtained most economically by raising the voltage on the whole system and then bucking down the voltage at the head of the feeder, as required, with regulators on individual distribution transformers.

Providing a suitable regulator inside the transformer leaves no choice for users but to stock two different types of distribution transformers. This amounts to multiplying the different distribution transformer kva ratings by the number of different voltages on that operating company's distribution feeders.

The logical choice was to place the regulator in a separate unit making one style applicable to a large range of distribution transformers with the regulator operating from the secondary voltage. This led to the development of UNOREG, the economical answer for solving complete feeders re-regulation problems as well as for correcting spot and emergency situations.

UNOREG consists of an indication regulator controlled by a solid-state voltage-regulating control.

This induction regulator has a new stator design which eliminates the need for a tertiary winding. Greater rigidity is achieved by means of a yoke-shaft rotor construction rather than using a through-type shaft. Self-adjusting, molded nylon bearings support the rotor in the center of the stator bore.

In keeping with the reliability of the induction regulator, the voltage control element is a static control which uses all solid-state components with no moving parts or contacts.

UNOREG smoothly corrects the input voltage without jumps or time delay by inducing a voltage in the series coils of the induction regulator which either adds to or subtracts from the input voltage.

The midpoint voltage setting of the regulator control is 122 volts, allowing for an average secondary drop of two volts. The control is designed so that the voltage is always corrected back to the center of the bandwith.

For maximum accuracy, the control is temperature compensated and meets the accuracy requirements of a class II voltage-regulating relay as defined by NEMA (National Electrical Manufacturers Association) standards. Encapsulation of the control makes it rugged, reliable, and tamperproof.

Laboratory tests show that every part of UNOREG is capable of operating for at least 20 years without failure. Data obtained from field tests indicate that the control range is held within the specified limit of ± 1¼ volts.

The new device is only 21½ inches high and 12¼ inches in diameter. Installation is simplified by the use of a lifting eyebolt and a mounting bracket with standard 12-inch bolt spacing. UNOREG has standard low-voltage distribution transformer bushings, color coded for quick and easy connection.

A totally new concept of distribution voltage regulation, UNOREG was specifically designed for solving voltage regulation problems through a system approach. In this type of application, the voltage is raised to the level needed by the large outlying areas, and then bucked down by regulators on transformers near the head of the feeder. However, many applications will be to boost low secondary voltage at the ends of long or heavily loaded feeders. EE

Natural Radioactive Gas Used as "Tracer" in Weather Studies

A naturally occurring radioactive gas has been used as a "tracer" to study how weather conditions affect air pollution, in experiments at the Argonne National Laboratory.

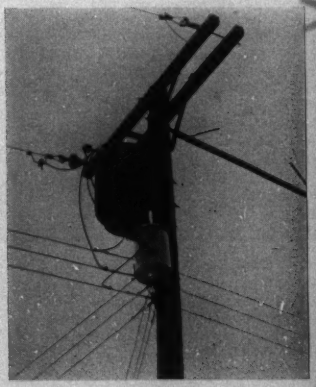
The gas is radon—a product of radioactive disintegration of radium atoms in the soil. It has been estimated that every square mile of soil to a depth of 6 inches contains approximately 1 gram of radium.

As radium steadily disintegrates by emitting alpha particles from its nucleus, it releases tiny amounts of radon through the soil into the atmosphere. The atmosphere contains on the average one part of radon to every billion billion (1 sextillion) parts of air.

Scientists in the Meteorology Group of Argonne's Radiological Physics Division measured concentrations of radon in the air each hour during three observation periods totaling 72 hours.

This enabled them to observe how varying weather conditions affected the atmosphere's ability to cleanse itself of pollution. They also discovered new information concerning the atmospheric distribution patterns of radon. The test extended from ground level to 130 feet.

Harry Moses, leader of the Argonne



MONTAGE of the complete UNOREG assembly (*left*) plus the two basic parts, the induction regulator and the voltage control box. *Right:* A 1¼-kva UNOREG installed with a 25-kva distribution transformer at the end of a residential feeder on the system of a large utility.

Meteorology Group, listed the following observations from the experiments:

1. At night, with clear skies and light wind, the atmosphere dilutes contamination very slowly, because there is very little vertical mixing between air currents. This was shown by the tendency of radon to "hug" the earth like a ground fog during the test period.

2. During the day, with the sun shining and wind blowing, the atmosphere mixes and dilutes contamination rapidly, as illustrated by the distribution of radon over greater heights.

3. The greatest concentrations of radon occur at ground level, and fall off sharply above that point.

4. Radon near the ground rises shortly after sunrise, because of convection arising from ground heating; i.e., lower air containing substantial concentrations of radon warms from the sun's rays and rises, as cooler air from above descends.

It was stated that this is the reverse of the usual process, in which pollutants descend to the earth from upper layers of the atmosphere at this time.

All radon levels observed were well beneath the maximum permissible concentration set by national and international committees on radiation protection.

5. Concentrations of radon are much greater at night in relatively still air than during the daytime, when the atmosphere is more turbulent. For example, the Argonne researchers found 20 times more radon in the air at a height of two to three stories at night than during the day. On cloudy, windy nights, concentrations decrease markedly.

6. Changes in weather conditions cause fluctuations of more than 100% per hour in the horizontal distribution of radon.

7. The atmosphere maintains a natural balance, in which as much radon is removed as is discharged into the air from the soil.

Participants in the project—in addition to Mr. Moses—were Dr. A. F. Stehney of Argonne's Chemistry Division, and H. F. Lucas, Jr., of the Radiological Physics Division.

These latter two devised new research techniques which enabled the group to obtain precise data showing how radon in the air varies with height and time.

In the 3-day project, scientists obtained air samples through a series of intake tubes mounted on top of a 130-foot weather tower at the Argonne Meteorology Station.

Air going into the tubes was measured, dehydrated, and passed through the charcoal filters, which trapped the radon.

The filters were removed, processed in the laboratory, and their radioactive content determined by means of a scintillation counter.

The next step was to compute how much radon is present per unit weight of air, by relating the amount of radon obtained to the volume of air from which it was extracted.

Scientists then related changes in the concentrations of radon in the air to changes in approximately 30 different meteorological variables. These variables are constantly measured at the Argonne Meteorology Station by special automatic recording instruments. **EE**

New Cryogenic Cooling Phenomenon

A phenomenon in the efficient transmission of liquified gases used for cryogenic cooling has been reported by The Garrett Corporation's AiResearch Manufacturing Company of Los Angeles, Calif.

Using unique, uninsulated lines, AiResearch has transmitted liquid nitrogen at —320 F over distances greater than 25 feet. Previously, 6 feet was the maximum.

Though the transfer lines used have no insulation or lagging, their exterior remains frost free and may be safely and

A NEW phenomenon, discovered by The Garrett Corporation's AiResearch Manufacturing Company, enables liquid nitrogen at —320 F to flow through this uninsulated tube without any discomfort when handled by the bare hand. The nitrogen is being collected in a Dewar flask, simulating an infrared detector cell used in missiles to search out enemy objects. Despite the near absolute temperature of the liquid nitrogen, the frost free tube could remain wrapped around the arm indefinitely. AiResearch uses liquid nitrogen to cool infrared detector cells which operate more efficiently at temperatures near —320 F.

comfortably manipulated with bare hands even though the liquid inside is —320 F.

The new technique, with patent pending, enables liquid nitrogen to be stored at a considerable distance from cooling areas without recourse to the cumbersome and expensive vacuum insulated lines previously required.

In missile applications, where refrigeration requirements are often concentrated in already crowded areas, the new transmission lines enable the supply vessel to be stored in another area.

A further advantage derived from the new transmission method is the ability to use flexible plastic lines which greatly simplify the delivery of cryogenic refrigerants to moving elements, such as gimbal or swivel mounted scanning devices.

Using the new technique, AiResearch has started production on a liquid nitrogen refrigeration system for an infrared detector. This system, which consists of a storage vessel, transfer line, and controls, maintains the infrared detector at a constant —320 F even though the liquid supply is located 25 feet from the detector head.

Infrared equipment functions more efficiently when cooled to cryogenic temperatures because of the reduction of thermal energy. This, in turn, reduces noise and provides a more favorable noise-to-signal ratio and more sensitive detection. **EE**

Giant Surveillance Radar Will Guard New York Areas

One of the largest long-range operational search radars in the world is in final installation stages at Montauk Air Force Station, Montauk, L.I., N.Y., the home of the 773D Radar Squadron.

Officials said the new high-powered air search radar installation will be completed in record time. Sperry Gyroscope Company, Great Neck, N.Y., is system manager—covering the design, development, manufacture, and installation of this unique radar system, called the *AN/FPS-35*—under the technical guidance of the Rome (N.Y.) Air Development Center.

Unofficially, the huge 85-foot concrete radar tower is the highest building on the tip of Long Island. The radar antenna, which adds another 40-feet to the tower's over-all height, weighs more than 80,000 pounds. Capable of withstanding winds up to 100 mph, it is power driven by six 100-hp motors. The antenna will rotate on a 7,500-pound ball bearing.

The long-range search radar is a much more sophisticated system than the exist-

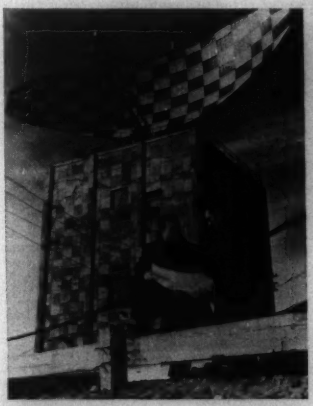


PHOTO of *AN/FPS-35* surveillance radar shows giant scanner atop 8-story concrete tower nearing completion at Montauk Air Force Station, L.I., N.Y. Frank Mulligan *(left)* and Lawson Singer, Sperry Gyroscope Company engineers in charge of the radar construction project, check final details of the high-power system which will help guard the New York area against air attack. When put into operation by the Air Force, the radar will feed position data on all air-breathing missiles and aircraft into high-speed computers which will automatically calculate intercept data for air defense systems in the area. Antenna measures 40 feet in height and weighs more than 80,000 pounds.

ing facilities at Montauk Air Force Station. The new radar will furnish search data on all friendly and unidentified aircraft to the New York Air Defense Sector computer for evaluation and action.

The 26th Air Division, comprised of the New York Air Defense Sector (to which the 773D is assigned), the Bangor, Boston, Syracuse, and Washington Air Defense Sectors, is responsible for the defense of 225,000 square miles of the heavily populated and industrialized eastern seaboard.

The FPS-35 program is the responsibility of Sperry's Surface Armament Division. EE

Autopilot for Light Planes Meets Airliner Standards

A low-cost automatic pilot, developed by Sperry Phoenix Company for the nation's business and private aircraft fleets, has been certificated by the Federal Aviation Agency (FAA) as having met standards set for airline equipment.

The new *SP-3* system, which the Sperry Rand division recently introduced as an "airliner-type" automatic pilot for light aircraft, was approved under T.S.O. (Technical Standard Order) regulations established by the Federal Government to govern quality of equipment used on transport-type aircraft.

Use of the *SP-3* equipment provides high levels of automation in flight, making possible maximum utility of the expanding fleets of light-to-medium aircraft. There are more than 95,000 planes in this general aviation category in the united States.

"While the *SP-3* system was developed to provide automatic control for all types of light twin- and single-engine aircraft, and not for airliners, it was designed to measure up to the most exacting known standards," R. B. Doe, Sperry Phoenix Company manager, stated. "Accordingly, we applied for, and received, certification from the FAA under terms of T.S.O. C-9B which covers automatic pilot equipment for transport-category aircraft."

Cost of the *SP-3* equipment ranges from $1,818 to $4,440, depending upon the level of automation desired—compared to the $20,000-to-$25,000 price of typical automatic pilot systems used aboard modern airliners. EE

Polyurethane Foam Packaging Guards Electronic Equipment

A shipping container utilizes the superior strength of polyurethane foam based on diisocyanates, such as the Nacconates produced by Allied Chemical's National Aniline Division (New York, N. Y.), to form an integral self-hinge.

The resilient container includes a cored bottom and a fitted, hinged top, both being cut from a single cube of black polyurethane foam. No assembly is required.

The hinged top is formed by slicing through the block of foam to within ½ inch of the end. The bottom of the container is then cored to accommodate a delicate electronic part, leaving thick walls to serve as a cushion and to absorb impact. Because of its design, the container firmly nests and protects the fragile component without the use of other protective packing, such as excelsior, shredded rubber, popcorn, or other litter-producing agents. The whole packaging unit is reusable.

BLACK polyester-based polyurethane foam was used to fashion this reusable shipping container. Cored sections will receive electronic component which must be protected against damage in transit. By sawing only to within ½ inch of rear face, lid of container is hinged without the need for assembly. Hinge may be operated hundreds of times without tearing the foam or destroying usefulness of shipping container.

Made by Paramount Foam Industries, Ridgefield, N. J., producers of colored slab-stock polyurethane foam, the container measures 10 by 8 by 12 inches and weighs only ¾ pound. Due to its light weight and lack of bulk, shipping charges are reduced. More important, however, is the assurance that the valuable cargo is safe from damage. The packing cannot break apart during shipment, even with rough handling. Unlike loose packing, foam cannot shift, thus holding the component rigidly in place, and guarding it against impact.

The flexible polyurethane foam produced by Paramount is the polyester type, ideal for interlinings and other applications requiring a very thin sheet. Slices as little as 1/16 inch thick are possible.

Although Paramount produces polyester-based polyurethane foam in seven standard colors—red, orange, yellow, blue, green, white and black—other shades to match a particular need can also be produced. However, because achieving an exact color in the foam involves several problems, nonstandard shades can be handled only when a full production run (minimum 100 feet) is ordered.

Of the seven colors available, black has been most in demand. It shows dirt least, a decided benefit when reusable containers have to be fashioned from it. EE

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

NUCLEAR PHYSICS AND ATOMIC ENERGY; TERMS . . . IN ENGLISH, FRENCH, GERMAN, RUSSIAN. By G. J. Béné and others. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J., 1960. 213 pages, 15 by 7½ inches, paper. $6. This 4-language glossary presents a 4-column list of equivalents alphabetized by the English term, each entry numbered, with supplementary lists in the other three languages keyed to this basic list. The Russian entries are not transliterated. This is the first of a series of glossaries, each bearing on one of the principal subjects discussed at international conferences.

ELECTRON TUBE LIFE FACTORS. Edited by Craig Walsh and others. Engineering Publishers, P.O. Box 2, Elizabeth, N. J., 1959. 173 pages, 8¾ by 11¼ inches, bound. $9.50. This book deals with the changes in the properties of electron tubes for periods of time up to 5,000 hours of life under various environmental conditions. The properties measured include transconductance, power output, operation, heater and grid currents, heater cathode leakage, grid emission, interface resistance, and interelectrode insulation. Results of measurements, including percentage of failure, under both test conditions and MIL standard conditions are given, as well as general material on the characteristics, properties, and ratings of tubes, the design and control of the tests, and the analysis, presentation, interpretation, and application of the data collected.

FEEDBACK CONTROL SYSTEM ANALYSIS AND SYNTHESIS. By J. J. D'Azzo and C. H. Houpis. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1960. 580 pages, 6¼ by 9¼ inches, bound. $13.50. First presented are the principles of obtaining differential equations for electrical, mechanical, hydraulic, and heat flow systems; the classical solution of differential equations, demonstrating the Laplace transform and the block diagram methods; and a detailed discussion of basic servo characteristics. Then such methods of analysis as root locus, frequency techniques, and compensation techniques, and optimum loss, a-c systems, nonlinearities, and computers are discussed. The final section presents some experimental methods, and synthesizes the methods presented throughout the book.

LOW FREQUENCY ELECTROMAGNETIC WAVE PROPAGATION OVER THE SURFACE OF THE EARTH. By Ia. L. Al'pert. Published by Morris D. Friedman, Inc., 1383A Washington St., West Newton 65, Mass., 1960. 98 pages, 8½ by 11 inches, paper. No price given. This translated study discusses computational formulas, the equation for the residues, the method of numerical computations, the results of field computations and their comparison with experimental results, and the influence of the sphericity of the earth. Included is a reprint of an article on investigation of wave propagation by the method of atmospheric shapes analysis.

QUESTIONS OF THE METALLURGY AND PHYSICS OF SEMICONDUCTORS. Edited by D. A. Petrov. Published by Morris D. Friedman, Inc., 67 Reservoir St., Needham Heights 94, Mass., 1960. 143 pages, 8½ by 11 inches, paper. No price given. This is a Russian translation of 19 technical papers which include discussion of current problems, methods of obtaining high purity silicon, and of obtaining single-crystal silicon with given electrical characteristics, chemical-compound semiconductors, alloys of the Bi-Te and Co-Sb systems, vitreous semiconductors, and impurities and etches of germanium and silicon.

CREATIVENESS FOR ENGINEERS. By D. S. Pearson. Third edition. Published by author, University Park, Pa., 1960. 150 pages, 5¾ by 8¼ inches, bound. $3.95. The author, a professor of electrical engineering, presents a philosophy and practice for scientific thinking. The history of creative thinking is outlined, and a general resumé of the qualities and qualifications for creativity is given. The volume considers problem solving for engineers, showing how to recognize, define, evaluate, and analyze a problem, and interpret its solution. Examples used include heating, vibration, and electromechanical analyses, and synthesis of equation, a spring-mass system, and a circuit breaker.

THE RADIO AMATEUR'S HANDBOOK. Thirty-seventh edition. Published by the Headquarters Staff of the American Radio Relay League, West Hartford, Conn., 1960. Various pagings, 6½ by 9½ inches, paper. $3.50. This annual revision of a handbook written with the needs of the practical amateur in mind, maintains its objective of presenting the soundest and best aspects of current practice rather than the merely new and novel. Major revisions are in the sections on the theory of radiocommunication, construction of equipment, vacuum tube characteristics, mobile radio equipment, and transistors. Other features are the manufacturers' catalog, instructions, abbreviations, and country call-letters for station operation, and extensive vacuum tube data tables.

BERICHTE DER ARBEITSGEMEINSCHAFT FERROMAGNETISMUS 1958. Published by Dr. Riederer Verlag, Stuttgart, West Germany, 1959. 136 pages, 8½ by 12 inches, bound. DM 48. One of a series of yearly reports of a competent German study group which aims to promote activity in the area of magnetics through research and contact with foreign authorities in the field. This particular volume includes some 24 papers. Among the topics discussed are: the Hall effect in ferromagnetic substances, investigations on the anomalies of the eddy-current, properties of the melting ferrite, spontaneous rectangular hysteresis loops in ferrites, the magnetic behavior of single crystals in Fe_2Al, etc.

THE THEORY OF OPTIMUM NOISE IMMUNITY. By V. A. Kotel'nikov. McGraw-Hill Book Company, 330 W. 42nd St., New York 36, N. Y., 1959. 140 pages, 7¼ by 10¼ inches, bound. $7.50. This verbatim translation of a 1956 Moscow publication is an extensive analysis of the effects of additive gaussian noise on communication systems and examination of noise-minimizing methods in reception techniques. The primary intention is to establish the behavior of communication systems at a practical level for the engineer, and only elementary notions of probability theory, and a minimum amount of advanced mathematics are employed. Extensive use is made of geometric models of the signaling and detection process as operations on vectors in multidimensional space.

WAVE PROPAGATION AND GROUP VELOCITY. By Léon Brillouin. Academic Press, Inc., 111 Fifth Ave., New York 3, N. Y., 1960. 154 pages, 6¼ by 9½ inches, bound. $6. Problems in connection with radio signals and radar, and in wave mechanics, have renewed interest in this field. Lord Rayleigh's definition of "group velocity" raised difficulties with the theory of relativity. This led to papers and discussions of the problem around 1910, and other definitions such as Sommerfeld's "signal velocity," and also the "velocity of energy transfer." Original papers and discussions pertinent to the evolution of these definitions, and applications such as guided waves, are presented in this book. The author has been closely connected with the development of wave propagation theories.

SOLID STATE PHYSICS, Volume 9. Edited by Frederick Seitz and David Turnbull. Academic Press, Inc., 111 Fifth Ave., New York 3, N. Y., 1959. 548 pages, 6¼ by 9¼ inches, bound. $14.50. This ninth volume of a series presenting advances in research and applications continues the emphasis on organic solids with the second half of an article on electronic spectra begun in vol. 8, dealing with the spectra of ions in crystals, and with an article on the electronic spectra of aromatic molecular crystals. Other papers discuss polar semiconductors, static electrification of solids, heterogeneities in solid solutions, the oscillatory behavior of magnetic susceptibility and electronic conductivity, and the interdependence of solid-state physics and angular distribution of nuclear radiations.

SOLID STATE PHYSICS, Volume 8. Edited by Frederick Seitz and David Turnbull. Academic Press, Inc., 111 Fifth Ave., New York 3, N. Y., 1959. 519 pages, 6¼ by 9¼ inches, bound. $13.50. This eighth volume in a series presenting advances in solid state physics research and applications begins a policy of focusing more attention on the properties of organic solids by presenting the first half of an article on electronic spectra, dealing with the electronic states of molecular crystals. Other papers discuss photoconductivity in germanium, interaction of thermal neutrons with solids, electronic processes in zinc oxide, and the structure and properties of grain boundaries.

SERVOMECHANISM FUNDAMENTALS. By Henri Lauer and others. McGraw-Hill Book Company, Inc. 330 W. 42nd St., New York 36, N. Y., 1960. 491 pages, 6¼ by 9¼ inches, bound. $10. The opening chapters present a detailed account of the basic properties of servo control devices, a presentation of the most usual "follow-up link" devices, and a review of the fundamental concepts of mechanics and electricity used in servo techniques. The operating features of servomechanisms are then discussed and their theory is developed through transient-response analysis methods, using classical methods in the solution of the differential equations. Chapters on transfer function analysis of servomechanisms, and nonlinear servo systems are included. The final chapter is composed of design problems and extension of servo control concepts to other applications, such as regulators.

SCIENCE AND RESOURCES. Edited by Henry Jarrett. The Johns Hopkins Press, Homewood, Baltimore 18, Md., 1959. 250 pages, 6¼ by 9¼ inches, bound. $5. Some of the difficult and critical questions arising from recent advances in science and technology are explored in this collection of papers originally presented at the 1959 Washington "Resources for the Future" Forum. A lead essay in each of the six topical sections discusses advances and state of current knowledge in a specific field, and is followed by two essays discussing the economic, social, and political impact of the advances. The six sections deal with human and animal genetics, weather control, geological exploration, chemical technology, nuclear energy and peaceful use of atomic energy, and space exploration.

PROGRESS IN DIELECTRICS, Volume 1. Edited by J. B. Birks, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1959. 312 pages, 6¼ by 9¼ inches, bound. $11. Intended for technologists in the many diversified areas utilizing dielectrics, this volume is the first of a planned series of annual reviews in the field. In electrical engineering the behavior of insulating materials under a wide range of operating conditions, electrochemical deterioration, and tests for insulation are of interest. The first articles deal with dielectric breakdown and insulating properties of solid, liquid, and gaseous dielectrics, and directional breakdown effects in crystals. Subsequent papers treat ferroelectricity, nonoxide ceramics, and the theory of electrophoretic deposition of insulation.

PRINCIPLES OF ENGINEERING ECONOMY. By E. L. Grant and W. G. Ireson. Fourth edition. The Ronald Press Company, 15 E. 26th St., New York 10, N. Y., 1960. 574 pages, 6¼ by 9¼ inches, bound. $8. Using the method of comparison of alternatives, this book is intended to serve both as a textbook and a working manual for those who make decisions about investments in capital goods. It gives basic principals for making practical decisions on the acquisition and retirement of capital goods, the choice of one of alternative methods of financing, and the consideration of income tax factors. Special attention is paid to capital rationing, mathematical analysis of compound interest, and operations research concepts. Features new to this edition include cash flow theory, various depreciation methods under United States tax laws and certain unsound criteria to avoid in evaluating investment proposals.

Library Services

ENGINEERING Societies Library books, except bibliographies, handbooks, and other reference publications, may be borrowed by mail by AIEE members for a small handling charge. The Library also prepares bibliographies, maintains search and translation services, and can supply a photoprint or a microfilm copy of any item in its collection. Address inquiries to R. H. Phelps, Director, Engineering Societies Library, 29 W. 39 St., New York 18, N. Y.

NUCLEAR POWER PLANT. By E. O. Taylor. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y., 1959. 184 pages, 5½ by 8¾ inches, bound. $7.50. This review of the basic ideas underlying nuclear power generation for the informed reader opens with a concise account of world energy requirements and resources in the present and in the future. It goes on to deal with nuclear and reactor physics and reactions, types of reactor according to different means of classification, reactor engineering based on the unique reactor physics, the control of the heat output of the reactor, instrumentation, and economics of nuclear stations. The appendices contain comprehensive tables of elements, neutron interaction formulas, reactor theory, and a chronology of nuclear power development.

JUNCTION TRANSISTORS IN PULSE CIRCUITS. By P. A. Neeteson. The Macmillan Company, 60 Fifth Ave., New York 11, N. Y., 1959. 139 pages, 6 by 9 inches, bound. $5.50. Methods are given which may be used to understand and analyze the fundamental pulse circuits containing transistors in electronic computers, portable and space-exploring apparatus, and other circuits for low-speed application, in order to simplify their design and production. Several basic circuits are surveyed: the free-running multivibrator and the blocking oscillator are examples of pulse generators; the monostable multivibrator and triggered blocking oscillator are regenerators; the bistable multivibrator can be a frequency divider or a level switch. In the final chapter, applications of these circuits, or combinations of them, are described.

INTERNATIONAL SYMPOSIUM ON THE THEORY OF SWITCHING, PROCEEDINGS, 1957. Published by the Harvard University Press, Cambridge, Mass., 1959. 2 volumes, 8 by 10¾ inches, bound. $15. An extensive presentation of various important aspects in the development of switches, switching theory, and applications since the advent of large-scale digital computers. The 39 papers published in these two volumes deal with abstract models of mathematical and logical theory; contact networks and network theory; magnetic and transistor logic, design and circuit considerations; switching systems and networks; and new types of switches such as the cryotron and chemical switching methods. They include developments in foreign countries as well as in the United States. These are volumes 29 and 30 of the Annals of the Computation Laboratory.

HÜTTE; MATHEMATISCHE FORMELN UND TAFELN. By I. Szabó. Wilhelm Ernst & Sohn, Berlin, West Germany, 1959. 287 pages, 6 by 8¼ inches, bound. DM 19.80. Starting with relatively simple mathematical operations, this collection of mathematical tables and formulas covers a wide range of topics up through advanced calculus. The first chapter contains the tabular material ranging from powers, reciprocals, etc. to elliptic integrals and Bessell functions. The following chapters deal respectively with the common divisions of mathematics, including explanatory text as well as formulas. A concluding section provides brief examples of "practical mathematics."

FLUORESCENT LAMPS AND LIGHTING. Edited by W. Elenbaas. The Macmillan Com-

pany, 60 Fifth Ave., New York 11, N. Y., 1959. 346 pages, 6 by 9 inches, bound. $11.75. This second edition of C. Zwikker's *Fluorescent Lighting* contains the recent advances in fluorescent lighting techniques and lamp construction. Stabilization of the discharge and ballasts for a-c operation are described and developments widening the use of tubular fluorescent lamps, including transistors, new circuits, ballasts, and reflector lamps are discussed. The subject matter of the book ranges from the physics of luminescence to public and private utilization of fluorescent lamps. The appendices discuss lamps with high loading per unit length and the application of transistors in lamp circuits.

ELEMENTS OF ION EXCHANGE. By Robert Kunin. Reinhold Publishing Corporation, 430 Park Ave., New York 22, N. Y., 1960. 164 pages, 5¼ by 7¾ inches, bound. $5.75. Specifically written for those with little or no theoretical background in physics, this small book provides a basic view of ion-exchange technology for executives, operating personnel, chemists, engineers, agronomists, and nuclear researchers. Most of the book is devoted to the fundamental theory of ion exchange: the nature of the materials involved, their structure, the techniques of testing and evaluation, and both general and specific principles of their application. Ion exchange engineering and design practice is also presented in a brief chapter.

ELECTRONIC COMPUTERS. By T. E. Ivall, Second edition. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y., 1960. 263 pages. 5¾ by 8¾ inches, bound. $10. This British book, also published in the United States, gives a nonmathematical general introduction to the principles and applications of computers employing tubes, transistors, and other electronic devices. Almost entirely rewritten with new diagrams and equipment photographs, this edition includes new chapters dealing with analog computer circuits, the programming of digital computers, and the evolution of the "intelligent" machines of the future.

ELECTRONIC CIRCUITS, SIGNALS, AND SYSTEMS. By S. J. Mason and H. J. Zimmerman. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1960. 616 pages 6 by 9¼ inches, bound. $12.50. The matrix, topological, and signal-flow-graph methods of circuit and system analysis presented are specifically applied to electronic circuit problems. The analysis and synthesis of pulse, periodic, and random signals dealt with is based on the correlation function and the Fourier integral and series; and transmission of signals through linear, nonlinear, and time-varying-linear systems is investigated. The negative feed-back concept in electronic control also is discussed.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

ENGINEERING INDEX 1959. For over 75 years The Engineering Index has served the engineering profession. It has been industry's authentic guide to periodical technical literature and a vital part of the engineer's reference equipment. It is useful to librarians, Government bureaus, educational institutions, and industrial organizations. The annotated reference items published provide a comprehensive digest of the important information on technical, scientific, and economic problems as recorded last year in engineering magazines, special bulletins, and Government reports gathered from all over the world. The volume contains annotations on over 30,000 articles in 249 fields of engineering interest and devotes over 100 pages to a list of authors covered in more than 1,500 technical periodicals. This publication may be ordered from the Engineering Index, Engineering Societies Building, 29 W. 39th St., New York 18, N.Y. for $70.

U. S. ATOMIC ENERGY COMMISSION PUBLICATIONS. *Radioisotopes in Science and Industry*. This report summarizes the Commission's Isotopes Development Program which is aimed toward accelerating the peaceful uses of radiation and reactor byproducts. It cites the uses of radioisotopes and radiation in agriculture and plant studies; their impact on medical diagnosis and therapy; their utilization in physical and chemical research; applications of radiation, etc. Price $1.25. *Proceedings of the 1959 Symposium on Low-Temperature Nuclear Process Heat* (TID-7580) reports the results of the AEC surveys of domestic process heat requirements; technical and economic factors peculiar to low-temperature nuclear process heat reactors; details of studies on low-temperature process heat reactors made at Argonne National Laboratory. Price 75¢. *Nuclear Science Abstracts, Vol. 14*, provides abstracts of the literature on nuclear science and engineering as well as immediate and detailed indexes. It covers research reports of the AEC and its contractors; research reports of Government agencies, universities, and industrial research organizations on a world wide basis; translations, patents, books, and articles appearing in technical and scientific journals. These three publications may be ordered from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

RESEARCH HIGHLIGHTS OF THE NATIONAL BUREAU OF STANDARDS. Describing a wide range of scientific studies, laboratory experiments, and instrumentation developments, this illustrated 169-page report brings together the most important developments in the research program of the Bureau during 1959. Much of the material is concerned with the new technology of the space age. Progress is reported in extending the calibration range of optical pyrometers from 2,400 to 3,300 C; the development of a high-current arc as a source of controlled temperatures; and the design of a special type of high-temperature resistance thermometer for interpolating between fixed points on the International Temperature Scale. Other research reported includes the refinement of atomic standards of length and frequency; confirmation of the Rydberg constant; establishment of a vibration pickup calibration service; and special measurements of the heat conductivity of explosives and solid propellants. This National Bureau of Standards Miscellaneous Publication 229, priced 55¢, may be ordered from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C.

ZENER DIODE HANDBOOK. A study of zener diodes and zener reference elements is prefaced by an introduction to semiconductor theory and reverse breakdown, and followed by a detailed and illustrated examination of design considerations, thermal and operating characteristics, and discussions of zener diodes: a-c applications, d-c applications, audio and r-f applications, computer and instrumentation applications, and circuit protection applications. The 100-page handbook is available from International Rectifier Corporation, El Segundo, Calif., $2 per copy.

SECTOR-FOCUSED CYCLOTRONS. The proceedings of a Conference on Sector-Focused Cyclotrons held in February 1959 have been published by the National Academy of Sciences. Edited by F. T. Howard, the 49 papers presented cover the design, construction, and testing of sector-focused cyclotrons. They include discussion of ion orbit theories, calculations of complex magnetic field configuration and factors affecting beam quality and control as well as problems encountered in the operation of fixed frequency cyclotrons. In addition to the text of the papers, the informal discussions of these topics by the members of the conference are given. A tabulation of the characteristics of 15 sector-focused cyclotrons which are either in operation or under construction is presented in an appendix. This publication 656 is available from The National Academy of Sciences-National Research Council, Printing and Publishing Office, 2101 Constitution Ave., Washington, D.C.

FIXED AND VARIABLE CAPACITORS. Written by G. W. A. Dummer, Royal Radar Establishment, England, and H. M. Nordengerg, U.S. Navy, this book provides a working knowledge of capacitor design and construction to aid in selecting and applying fixed and variable capacitors in modern electronic equipment. It brings together for the first time in book form information previously available in widely scattered technical publications. Characteristics and applications of paper, mica, ceramic, glass, vitreous enamel, electrolytic, gas-filled, and other fixed capacitors are covered in the book. It also provides information on the full range of variable capacitors such as general purpose, precision, transmitter, trimmer, and special types. Construction details of fixed capacitors are described according to the dielectric materials used in the capacitors. Included is general information on both types of capacitors. Failures which may occur in capacitors are discussed, as well as future potentials and possibilities, and new types of experimental capacitors. The volume may be ordered from McGraw-Hill Book Information Service, 327 W. 41st St., New York 26, N.Y., for $10.

PLATED-THRU HOLES FOR THRU CONNECTIONS ON PRINTED WIRING BOARDS. With increasing production of more complex electronic systems, particularly for military equipment, the reliability of through connections on 2-sided printed wiring boards is the subject for this 59-page report. Published by Photocircuits Corporation, it contains a number of independent studies made by major suppliers of military electronics, as well as findings of the company's test laboratories. Included are 40 charts and illustrations. Copies of the report are available for $1 from the Publications Department, Photocircuits Corporation, Glen Cove, L.I., N.Y.

PROCEEDINGS OF THE 1959 EASTERN JOINT COMPUTER CONFERENCE. This 260-page volume contains 31 papers prepared for presentation at Boston, Mass., during December 1959. They cover a wide range of subjects of special interest to everyone concerned with the development and manufacture of computers and with their use in scientific and business applications. It has hundreds of illustrations and complete transcripts of the discussions held in connection with each paper. Copies at $3 each may be ordered from the Institute of Radio Engineers, 1 E. 79th St., New York 21, N.Y.; the American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N.Y.; or the Association for Computing Machinery, 2 E. 63rd St., New York 21, N.Y.

DEVELOPMENTS IN THE SITUATION OF EUROPE'S ELECTRIC POWER SUPPLY INDUSTRY DURING THE POST-WAR PERIOD. Prepared by the Secretariat of the Economic Commission for Europe this United Nations document is intended to provide information on developments in Europe's electric power supply industry during the postwar period. In addition to an analysis of developments in the situation, the volume contains series of data which may serve as a basis for studies at the national level. It is divided into four chapters: Consumption of Electric Power; Electric Power Production; Electric Power Production and Transmission Equipment; International Transfers and Exchanges of Electric Power. The publication may be obtained from Columbia University Press, 2960 Broadway, New York 27, N.Y., for $1.50.

CATALOG OF LIGHTING DEMONSTRATION AND EXHIBIT MATERIALS. Prepared to aid electric utilities in planning effective lighting presentations, this catalog will prove helpful to anyone wishing to build demonstration equipment. Illustrations and accompanying dimensional information are supplemented by drawings. The catalog may be ordered from Edison Electric Institute, Sales Division, 750 Third Ave., New York 17, N.Y. The price to EEI member companies is $2, to nonmember and foreign companies $3.

THE LIGHTING OF A GREAT MUSEUM. The reasons behind the Guggenheim Museum lighting are given in an illustrated monograph which sheds light on some of the most controversial aspects of Frank Lloyd Wright's structure. Copies of this booklet may be ordered from American Lighting Corporation, 164 South Street, Hackensack, N.J. for 50¢ each.

New & Improved Products

(*Continued from page 20A*)

Damping Compound . . .

When sprayed or trowelled on the plate to be damped, this new viscoelastic material will reduce to a considerable extent structurally borne noise and vibration. Called Vibrodamper, the compound solves severe resonant tendencies that may occur in sheet metal chassis, aircraft structures, and equipment housings. Until now, emphasis has been placed upon developing stiffer structures to raise natural frequencies. Application of the new material, however, will offset this requirement. Chassis, base plates, printed circuit boards, sealing covers, computer brackets, amplifiers, inertial platforms, gyros, and power supplies are some of the structures that lend themselves to this material. *The Korfund Co., 48-78 32nd Place, Long Island City, 1, N. Y.*

Storage Cathode-Ray Tube . . .

The *FW-211* Iatron, newest of a family of storage tubes, is the brightest, lightest, and smallest component of its type. Used as a panel-mounted radar or infrared indicator in aircraft, its fast writing and high deflection speed permit accurate and instantaneous presentations. A specially developed coaxial electron gun system eliminates trapezoidal distortion of the scanning pattern. Other distinctive features include full daylight viewing of electric signals by image intensification, and the ability to write, store, and erase information at will. A display exceeding 4,000 foot-lamberts brightness is obtained at a phosphor voltage of only 8.5 kv. *ITT Laboratories, Fort Wayne, Ind.*

3-Dimensional TV . . .

Believed to be the first commercial 3-dimensional closed-circuit television available, this new system consists of two standard cameras linked as a unit, a dual monitor control console, and a simple polarized optical system for viewing the object in stereo. Perhaps the most important use of the system will be for viewing and manipulating radioactive substances in danger zone areas where intricate production or test operations can be greatly facilitated through 3-dimensional viewing. *KIN TEL, Div. of Cohu Electronics, Inc., 5725 Kearny Villa Rd., San Diego 11, Calif.*

Magnetic Memory Control . . .

The Magnastat is a compact, reliable magnetic memory disc adaptable to materials handling where a time delay factor is present. Activated manually or by limit switches, as well as by weight or size, the system makes it possible for a processing decision to be made at one point in the production line, and then by storing this decision on the magnetic disc, it assures automatic execution of any desired operation at a later stage in the production line. Lacking electronic parts, this simple, rugged magnetic memory system will provide complete control of grading, sorting, filling, marking, wrapping, stamping, or trimming operations on conveyed products of any type or size. *Republic Electric & Development Co., 2627 Western Ave., Seattle 1, Wash.*

Character Display . . .

Ultra-high-speed and brilliantly clear character reproductions can be displayed from computer or tape output directly to the cathode ray screen with this development called the Vidiac (visual information display and control). Designed for fast visual communication between operator and machine, the device uses solid-state circuitry to take the place of metal type and graphic originals. Depending upon the degree of read-out quality and character variety desired, the Vidiac can display 5,000 different varieties of type styles at 1,000 characters per second with a graphic arts quality of a 5,000 television picture element resolution. Or, if desired, as many as 100,000 characters per second may be displayed with a reduced selection of 150 character style variations and a 100 television picture element resolution. *CBS Laboratories, High Ridge Rd., Stamford, Conn.*

po-si'tion

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Plan your future with Nortronics' Norwood team and stimulate your professional growth. If you can qualify in one of several electro-mechanical areas you will work on challenging programs with professionally dedicated associates.

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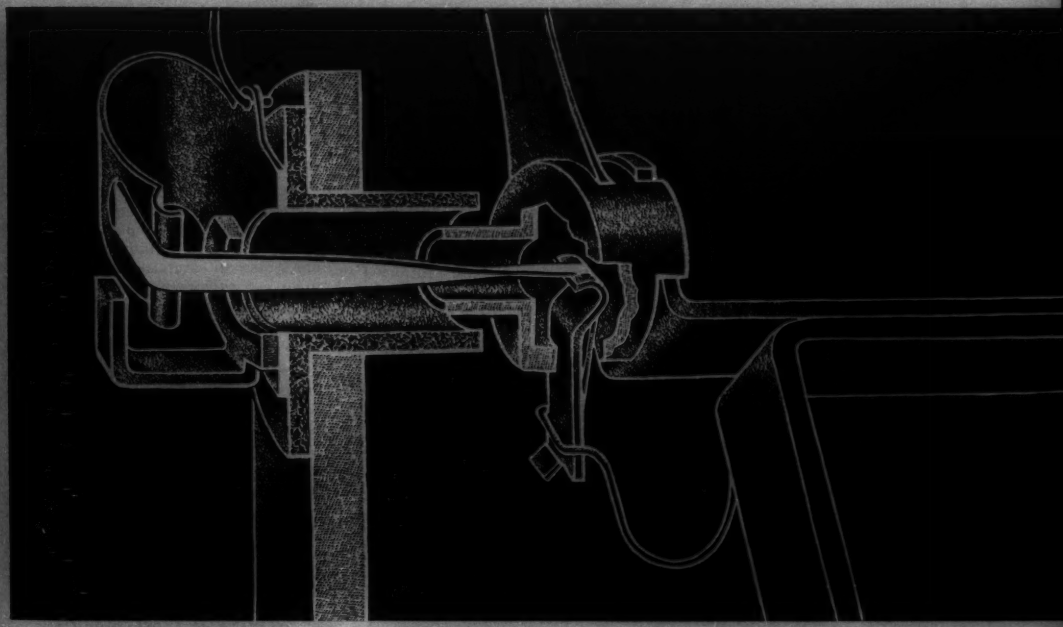
As a result of the outstanding performance records and customer preference established by thousands of Westinghouse TBS* instruments in all types of applications during the past year, this revolutionary new instrument design has now been extended to the full line of our switchboard instruments. These include the full-view 4½" circular scale, and 6" rectangular 100° scale designs. This remarkable development, introduced by Westinghouse in 1958, enables Westinghouse instruments to withstand extreme vibration and shock that adversely affect any other instrument. Users have found, too, that TBS offers *complete freedom from replacement of pivots, bearings and springs* . . . a significant saving in instrument maintenance costs. All types also meet or exceed ASA Specification C39.1 for switchboard instruments.

Exhaustive tests, conducted over a period of more than three years, included the most severe shock and vibration conditions that could be imagined for instruments. Field performance has more than justified our expectations. Application data derived during this period will help us continue to lead the industry in developing more accurate and reliable instrumentation for you.

Elimination of the conventional pivots and bearings provides an extremely rugged unit . . . eliminates friction . . . provides higher sensitivity . . . and results in almost infallible repeatability. For example, the Type KX-241, 250° full-view instruments



There's no wear here

Notice how the conductor clears the clamp end with plenty of room for movement? There are no sharp edges to chew into it, shortening service life. This is just one of many features designed into O-B Strateline clamps. Others are:

KEEPER-PIECE permanently attached to U-bolts simplifies installation and hot line working.

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ADEQUATE HOLDING POWER for normal distribution requirements.

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BROAD SELECTION OF CLAMP SIZES from .15-inch to 1.55-inch conductor diameters.

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O-B has designed into this clamp the extra features you need for convenient, dependable deadends. Why not order O-B Strateline clamps for your next distribution deadend construction!

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Industrial Notes...

Simplatrol Products Corp. Worcester, Mass. . .

A Simplatrol electric clutch and brake assembly was selected recently by the Electronic Data Processing Division of Radio Corporation of America to serve two vital functions in the high-speed electro-mechanical printer of its new *501* Data Processing Unit. In the tape drive section of the unit, the Simplatrol *CB-62* electric clutch-brake assembly both feeds the paper and simultaneously aligns it for accuracy. Both operations are performed at extremely high speeds. According to RCA engineers, the Simplatrol unit was specifically selected for these purposes because of its remarkable consistency, smoothness, and quietness. The unit possesses only one moving part, a patented diaphragm. Similar units are available with fixed fields and in a wide range of sizes to meet broad industrial applications. Simplatrol Products Corp., 24-6 Salisbury St., Worcester, Mass.

Chromalloy Corp. White Plains, N.Y. . .

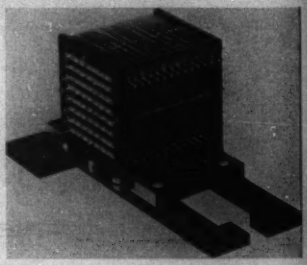
A molybdenum wire can glow at a white-hot 2,400 F. The secret of this trick is that this particular piece of fine wire has been chromallized. Normally, molybdenum oxidizes very rapidly, and, at 2,400 F, would disintegrate in a matter of seconds. However, by diffusion coating the wire with chromium and other elements, Chromalloy Corp., 452 Tarrytown Rd., White Plains, N. Y., developers of the process, have vastly improved the metal's oxidation resistance, making it suitable for many high-temperature applications.

ACF Industries, Inc. Alexandria, Va. . .

Human factors that influence the design of space-age electronic equipment will be the subject of a joint research program by The Catholic University of America and the Electronics Division of ACF Industries, Inc., 1332 N. Henry St., Alexandria, Va. Under the agreement, the University, located in Washington, D. C., will supply personnel and facilities of its experimental and physiological psychology laboratories; ACF Electronics will contribute engineering and production support as well as the services of its human factors department.

National Cash Register Hawthorne, Calif. . .

A megacycle rod memory has been delivered to the Naval Ordnance Test Station, China Lake, Calif., by the National Cash Register Co. (NCR). Navy scientists plan to use



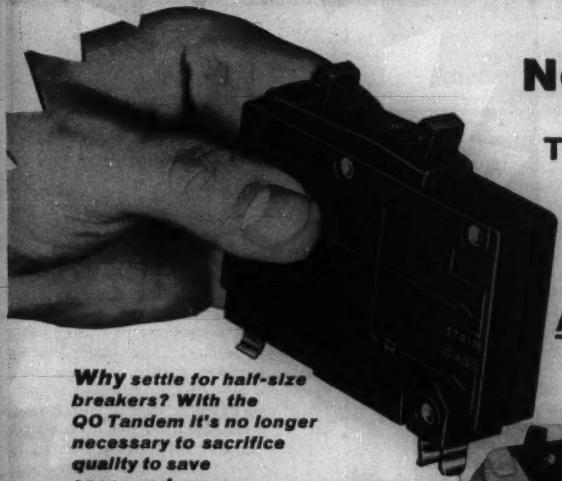
this unit as a computer buffer memory for sequencing and control of automatic data-handling equipment for their NODAC (Naval Ordnance Data Automation Center) Facility. The memory should be able to replace a number of high-speed flip-flop registers. Developed around the NCR magnetic rod at NCR's Electronics Division, the rod assembly consists of glass rods of 0.010-inch diameter which are electroplated with a magnetic alloy and wound with many small coils. The complete read-write cycle, including access time, requires only 1 microsecond. It has operated over a temperature range of −100 to +200 C without appreciable change in its switching characteristics, and can be switched in less than 50 millimicroseconds with moderate currents. Both the plating process for the rod element and the assembly of the rod can be completely automated.

Electronic Counters, Inc. Long Island, N.Y. . .

Electronic Counters, Inc., formerly a division of Potter Instrument Co., announces the occupancy of its new manufacturing plant at 155 Eileen Way, Syosset, L. I., N. Y. According to the company's president, N. A. Moerman, an extensive program of expansion of its Digimeter line and increased sales effort is planned in order to capture a greater share of the electronic counter equipment market.

(Continued on page 38A)

HERE'S THE big NEWS IN CIRCUIT BREAKERS!



Square D's New QO Tandem combines Two Full Size Breakers IN ONE SPACE-SAVING UNIT!

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Still Maintains ALL the QO Features PLUS these NEW ONES!

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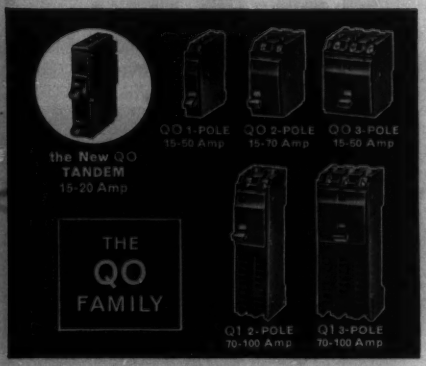
the New QO TANDEM 15-20 Amp
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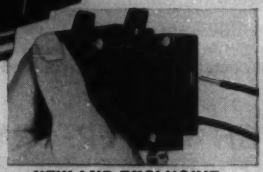
QO 2-POLE 15-70 Amp
QO 3-POLE 15-50 Amp
THE QO FAMILY
Q1 2-POLE 70-100 Amp
Q1 3-POLE 70-100 Amp



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Fast, positive connections. Holds on 5000 amp shorts.

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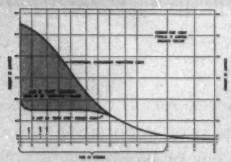
Doubles the number of 15 and 20 amp double-pole breakers. Uses QO handle tie.



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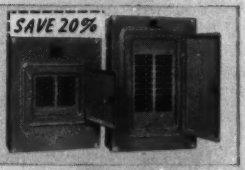
Magnetic opens on first flash. Thermal holds on overloads. No known protection is faster.



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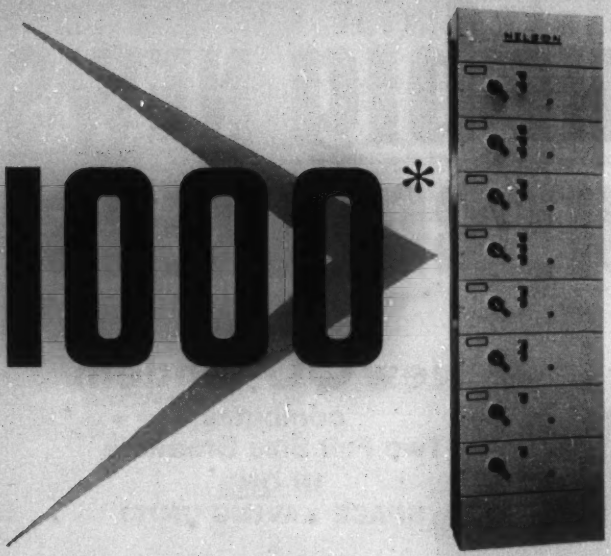

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This record of proven performance again confirms the fact that Nelson is

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Be sure to let your Nelson representative figure your next job. You will find him listed in the Yellow Pages of major city telephone directories.

If *quick shipment* on Motor Control Centers is of importance to you, ask for a copy of Nelson's new *QUICK-TROL* Bulletin.

** *Ask your Nelson man for the name of the industry and the facts.*

NELSON *Electric* MANUFACTURING CO.
TULSA, OKLAHOMA
P. O. BOX 5885 RIVERSIDE 2-5531

Industrial Notes

(Continued from page 36A)

RCA
New York, N.Y. . .

RCA Communications, Inc., has increased its transatlantic communications network by the addition of more than 50 telegraph channels in new coaxial cables linking the United States with Great Britain, France, and Germany. The new cable facilities supplement RCA's primary international radio circuits to provide telegraph, telex, and private leased channel communications. Sixty additional cable channels will be added at a later date.

American Time Products, Inc.
Long Island, N.Y. . .

This company has moved to 61-20 Woodside Ave., Woodside 77, L. I., N. Y. The new quarters, which nearly double former production capacity, were required in order to meet immediate manufacturing schedules and to provide for the rapidly increasing volume of business. The larger space makes possible a greatly expanded program including increased research and development work, more intensive testing and inspection, as well as accelerated production for quicker deliveries.

Republic Aviation Corp.
Farmingdale, L.I., N.Y. . .

Half-inch cube modules, each holding anywhere from 12 to 18 components and weighing only 2 grams, will be used in the guidance system of the AN/USD-4 "Swallow" reconnaissance drone that is being built for the U. S. Army Signal Corps. The module is said to be suitable for use in any all-purpose digital computer, whether for military or commercial use. It has a packing density of a quarter of a million parts per cubic foot, or five times the density attainable through standard circuit techniques. One of the main design features of the new module is its encapsulation. The encapsulating material used here, an excellent heat conductor, eliminates so-called "hot-spots" by evenly distributing the heat. It also seals the circuit against moisture. Another feature stressed by the designers is the use of standard components. The modules are being manufactured by Republic Electronics Tooling Department.

(Continued on page 40A)

WESTON FAN SHAPES OFFER EXTENDED SCALE LENGTH, MULTIPLE RANGES

Designed for accuracy... engineered for long life

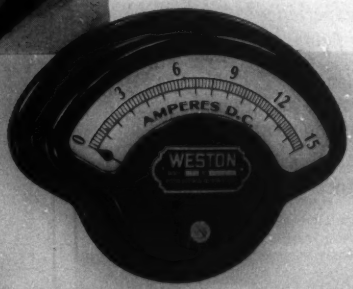
Weston's fan shaped switchboard instruments are well known throughout the industry as standards of long-term dependability. The number of uses for these quality DC meters is legion. They are frequently specified for temperature measurement, speed indication and other applications where their long scale length and accuracy of ±1% are important.

Exceptional scale length is achieved through classic Weston design. Model 273, for example, provides a 7.32" scale in less than 9.5 x 7.5" of panel space. For extremely precise measurement, these meters can be supplied with knife-edge pointers and mirror scales.

Shielded cases are of pressed steel for maximum strength and immunity to stray fields. Cases are surface type, back connected.

Ranges depend on intended use. Weston fan shaped meters are supplied from 100 microamperes full scale, and 10 millivolts full scale.

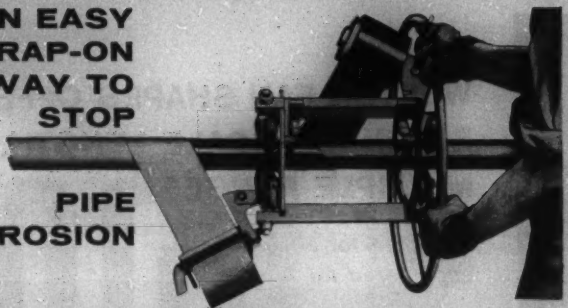
Call your Weston representative for details, or write for Catalog 01-200 which contains full technical data. Daystrom, Incorporated, Weston Instruments Division, Newark 12, N. J.
International Sales Division, 100 Empire St., Newark 12, N. J.
In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ontario.



Permanent magnet moving coil type. Supplied with dull black finish. DC ranges as specified. Maximum required panel space and scale length: Model 267–4-3/32 x 3-3/8", 2.6" scale. Model 269–5-5/8 x 4-7/16", 4" scale. Model 271 – 7-7/8 x 6-1/4", 5.8" scale. Model 273–9-5/16 x 7-13/32", 7.32" scale.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION
Reliability by Design

AN EASY WRAP-ON WAY TO STOP PIPE CORROSION



CHASEKOTE* Pressure-Sensitive Polyethylene Tape has an extra-heavy adhesive mass that clings to clean pipe on contact . . . makes a perfect, permanent bond that rustproofs, waterproofs and insulates pipe against all types of corrosion.

CHASEWRAP* Protective Overwrap is a tough, wrinkle-free outerwrap that shields against abrasion, wear, and physical damage to the tape. Wraps simultaneously with the tape. Superior to rag and felt wraps, yet far lower in cost.

*Trade name of Chase & Sons, Inc., long-famous for protective and insulating tapes for electrical wire and cable.

The new CORR-PREV Pipe Coating Team comes in easy to handle tape form. It goes on pipe faster and lasts longer than corrosion-proof paints. It's cleaner and simpler to apply, too, than hot tar coats. And most important, this new CORR-PREV Team offers all the cost-cutting, pipe-saving advantages of polyethylene tape.

With CHASEWRAP Abrasion-Resistant Overwrap and Chasekote polyethylene tape, you get the easiest and best pipe protection at lowest applied cost! There's no heating, drying, clean-up or shut-down time. Each roll is factory-uniform in thickness and quality. And all coating materials — including rental of high-speed applicators — are available from one reliable source. Want samples? Specs? Prices? Write **CHASE & SONS, INC., 26 Spruce Street, North Quincy, Massachusetts.**

CORR-PREV DIVISION

FOR YOUR ELECTRICAL INSULATION PROBLEMS SPECIFY CHASE FRICTION, PLASTIC, RUBBER, NEOPRENE & BUTYL TAPES

Professional Opportunities Are Available For

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UPTON, LONG ISLAND, N. Y.

BROOKHAVEN NATIONAL LABORATORY
A Center for Nuclear Research and Development
UPTON-NEW YORK

Industrial Notes

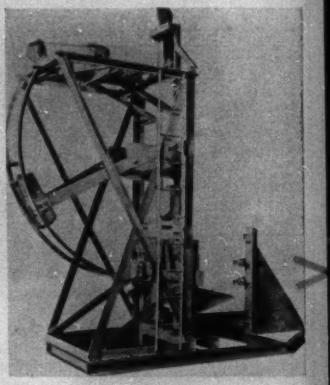
(*Continued from page 38A*)

MB Electronics New Haven, Conn. . .

One of the world's largest single-unit underwater transducers, to be hydraulically driven, has been ordered by the Bureau of Ships, U. S. Navy, from MB Electronics, a division of Textron Electronics, Inc. The unit will be for use at the Navy's Underwater Sound Laboratory in New London, Conn., and is to be completed and delivered by MB late in 1960. It is part of a major contract given to the company for the design and development of a new type of underwater (sonar) transducer. With no inherent system limitations, pressures as high as 3,000 psi are common. Heart of the new transducer which will provide extended frequency range at high output power will be MB's type *HV* electrodynamically excited hydraulic servo valve.

Bethlehem Foundry and Machine Bethlehem, Pa. . .

A high-impact shock test machine manufactured by the Environmental Engineering Division of



Bethlehem Foundry and Machine Co. is used for testing the reliability of military equipment to a near-miss in bombing raids. The machine carries out test specifications in MIL-1-16400A which is called for in military procurement of land-based and shipboard equipment. It is built in two models—for testing both lightweight specimens (up to 250 pounds) and medium-weight specimens (up to 1,200 pounds).

SALES ENGINEERS

We are placing on the market several new products including recording and controlling instruments and require Sales Engineers for our Houston, St. Louis, Chicago, Detroit, and Cleveland districts. Prefer Electrical, Mechanical, or Chemical Engineers. Can offer excellent opportunities for qualified men. Successful candidates will be given a factory course at Waterbury before assignment to one of the above districts. Write Mr. H. E. Beane, Vice President, The Bristol Company, Waterbury 20, Connecticut.

ELECTRICAL ENGINEER

One of the country's leading manufacturer's of fine papers has opportunity for graduate electrical engineer.

Work involves plant engineering assignments including design, cost estimating, specifications and equipment selection.

Applicants should have 3 to 5 years of industrial experience, preferably pulp and paper mill.

Company offers full benefits and excellent working conditions.

Submit summary of experience in confidence to:

Industrial Relations Department
Hammermill Paper Company
Erie 6, Pennsylvania

Trade Literature...

Test Cooling with CO_2 . . .

The use of carbon dioxide systems for extremely fast cooling and absolute control in environmental testing is described in a new booklet put out by Cardox Division of Chemetron Corp. Illustrated is the Cardox vapor recycle system, which provides vapor-free liquid at the point of use under all operating conditions. Also discussed and diagrammed are five other methods of reducing test chamber temperatures with carbon dioxide; and dry ice chamber, the immersion tank method, the brine circulation method, open carbon dioxide discharge, and the closed loop system. Nine advantages of Cardox CO_2 cooling over mechanical refrigeration for environmental testing are presented, and the Cardox bulk liquid storage tank, which can be installed inside or outside the plant, is diagrammed with charts showing dimensions of the tank units and of recommended foundation slabs. For Form C-7, write to *Cardox Division of Chemetron Corp., 840 N. Michigan Ave., Chicago 11, Ill.*

Silicon Rectifier Package Booklet . . .

A new booklet tells why silicon rectifier packages offer d-c power savings to the electrochemical and allied industries. Entitled "Power Savings for the Electrochemical Industry with Westinghouse Silicon Rectifiers," the 20-page publication presents a detailed description of a silicon power package and states the advantages of silicon over other rectifying methods. For booklet B-7900, write to *Westinghouse Electric Corp., P.O. Box 2099, Pittsburgh 30, Pa.*

Filtoroid Cores Booklet . . .

A completely revised 12-page bulletin on Powdered Permalloy Filtoroid Cores presents extensive information on core loss and Q calculation data, inductance variation with temperature, and induction variation with direct current. Tables cover such subjects as core dimensions and tolerances, types of finishes, electrical specifications, standard core sizes, and types of core specifications. The brochure is also supported by detailed curve-graphs on typical inductance vs. flux density, typical core loss on different types of cores, and changes of inductance at various temperatures, as well as inductance variation with direct currents. *Magnetic Metals Company, Hayes Ave. at 21st St., Camden, N.J.*

Manual on Hermetic Sealing . . .

A new manual issued by the Electro-Seal Corporation details the basic steps and applications for electro-sealing, an improved process for hermetic sealing which was developed for military requirements and is now being widely employed in many commercial products where improved reliability is desired. By means of the new electro-seal process, entire assemblies as well as single electric, electronic and mechanical components can be hermetically sealed. The manual illustrates applications such as complete timer mechanisms, electronic amplifiers, and centralized remote control gear for power stations that have been hermetically sealed by the electro-seal process. Manual AA may be obtained from *Electro-Seal Corp., 946 A North Ave., Des Plaines, Ill.*

Compressed-Sheet Mica Products Catalog . . .

A completely revised catalog showing the entire line of mica products made by The Macallen Company, Inc. has just been announced by Insulation Manufacturers Corporation of Chicago. The 24-page catalog, No. 26, covers technical information on Macallen's mica hard plates; flexibles and flexible combinations; micapaper rolls, sheets, and tapes; as well as fabricated parts made to customer specifications. It also includes National Electrical Manufacturers Association specifications for manufactured mica sheets and wrappers. A valuable section of this pamphlet deals with the limitations of natural mica and the resultant development of compressed-sheet mica. Data on grading and classfying, types, properties, and processing of natural mica is included. Available on request from Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.

Alarm Control Bulletin . . .

A bulletin on a high-capacity alarm/control system providing an inexpensive method of locating faults at unattended remote operations and controlling "on-off" functions remotely has been issued by General Electric. The publication describes how the user may "customize" the equipment to meet a variety of specific supervisory or control needs. A basic system consists of a Master Interrogator unit and from one to ten Remote Responders. A pulsed tone is transmitted through the network and returned, giving positive indication of alarm or control functions. Bulletin ECM 119 is available in single copies without charge from *General Electric Communication Products Dept., P. O. Box 4197, Lynchburg, Va.*

(*Continued on page 52A*)

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Official monthly publication containing articles of broad interest, technical papers, digests, and news sections: Institute Activities, Current Interest, New Products, Industrial Notes, and Trade Literature. Automatically sent to all members and enrolled students in consideration of payment of dues. (Members may not reduce the amount of their dues payment by reason of nonsubscription.) Additional subscriptions are available at the nonmember rates.		annually $12* Single copies $1.50*	$1.00
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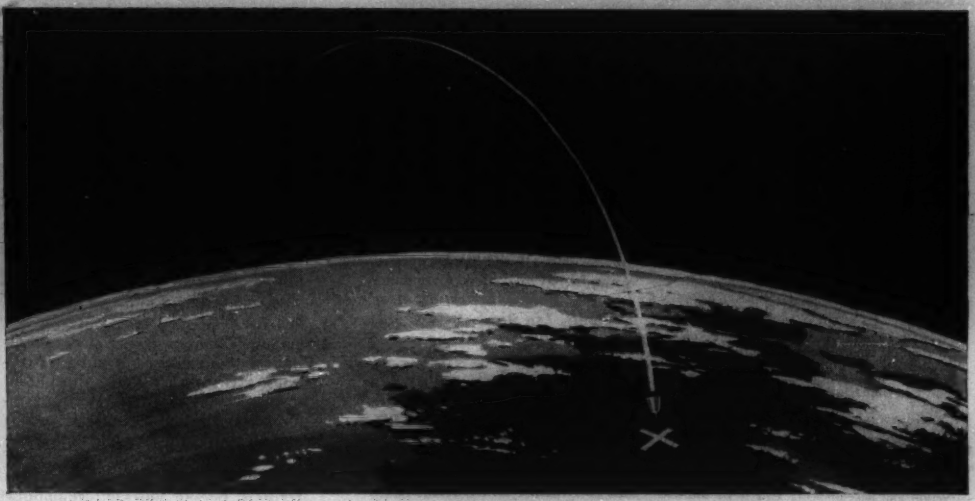
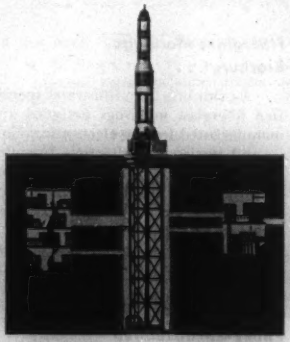


ASSIGNMENT: HIT A TARGET 6000 MILES AWAY

Can you guide a 110-ton Air Force Titan missile far up into the sky, to bring its nuclear warhead down with pinpoint accuracy on a target one-fourth the way around the globe—a target you not only can't see but which continually moves with the spinning earth?

This was the problem in missile guidance the Air Force presented to Bell Telephone Laboratories and its manufacturing partner, Western Electric. The answer was the development of a command guidance system which steers the Titan with high accuracy.

Unlike self-contained systems which demand complex guidance equipment in the missile itself, Bell Laboratories Command Guidance System keeps its master control equipment on the ground where it can be used over and over again. Thus a minimum of equipment is carried in the missile, and the ground station has full control of the missile during its guided flight. Techniques drawn from the communications art render the system immune to radio jamming.



Bell Laboratories scientists and engineers designed the transmission and switching systems for the world's most versatile telephone network, developed much of our nation's radar, and pioneered in missile systems. From their vast storehouse of knowledge and experience comes the guidance system for the Titan.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

CLASSIFIED ADVERTISING

For help and situations wanted, $2.25 per line, minimum 5 lines, maximum 30 lines. Sale and purchase of used machinery, etc., $3.00 per line, not available to dealers. Address orders to: Classified Section, ELECTRICAL ENGINEERING, 6th Floor, 33 West 39th Street, New York 18, N. Y.

When answering an advertisement, send all replies to box number specified, c/o ELECTRICAL ENGINEERING, 6th Floor, 33 West 39th Street, New York 18, N. Y., unless other address is given.

Positions Open

PROFESSOR OR ASSOCIATE PROFESSOR of Electrical Engineering to teach and do research in the field of communications. Should have Ph.D., teaching and research experience. Write Box 56.

WANTED—ELECTRICAL ENGINEERS. Minimum five years experience in Public Utility Distribution, Transmission, Metering and Relaying. Required for permanent, responsible positions in Venezuela. Spanish an asset but not essential. Good living conditions. Starting salary of $13,000 per annum. Write to Box 78.

SYNCHRO DESIGN ENGINEER. Electrical engineer with several years design experience in synchro and related precision components with well established company in the component field. This position will involve long range development to expand existing component lines. All replies will be acknowledged. Please forward in confidence your complete resume to: Robert J. Newton, G-M Laboratories, Inc., 4300 N. Knox Avenue, Chicago 41, Illinois.

ELECTRICAL ENGINEER, B.S. in Electrical Engineering with Power option. A current graduate or a man with up to two years of industrial experience in electrical maintenance, construction and development. This is an addition to the Staff Engineering Department concerned with technical assistance in design of new plants, consulting on improvements to existing plants and development of controls. Starting salary commensurate with education and training. Write outlining personal data, experience and salary requirements to Box 90.

ASSISTANT OR ASSOCIATE PROFESSOR for Electrical Engineering Department. M.S. or Ph.D. degree required. Opening in electronics. Salary commensurate with qualifications. Position available September 1960. Write Head, Electrical Engineering Department, South Dakota School of Mines and Technology, Rapid City, South Dakota.

APPLICATION ENGINEER: EE. 39. 7 years experience heavy ground and airborne radar including installation, operation, and maintenance. Digital computer schooling. Single. Will travel. Desire job satisfaction and job responsibility. Write to Box 92.

ELECTRICAL ENGINEER. 27, single. Desires challenging position with technical and supervisory responsibility leading to management. Three years broad experience in design and manufacture of electronic navigation and communication equipment. Two years military supervisory experience in operations, installation and maintenance of same. Prefer midwest. Write to Box 91.

TEACHING POSITION. Expanding department, seeks a well-qualified person who is interested primarily in teaching. Attractive twelve-month plan available. Location—private university in Midwest. Send complete resume to Box 94.

ELECTRICAL ENGINEER. Board layout work-power, lighting, and control systems; calculations; and occasional field contacts. Extremely wide variety of work with opportunity to enter consulting field and grow with progressive midwestern concern. Write to Box number 95.

ELECTRICAL ENGINEER—To design and prepare plans, specs and estimates of cost for construction or maintenance of electric systems for Department of Public Works. Accredited degree in electrical engineering; 3 years field and office experience. $7,086—$8,382 annually; sound pension system including social security; liberal paid holiday and vacation. Formal application must be on file by 4:00 P.M. August 3, 1960. MILWAUKEE COUNTY CIVIL SERVICE COMMISSION, Room 206, Courthouse, Milwaukee 3, Wisconsin.

Trade Literature

(*Continued from page 49A*)

Servo Design Simplified . . .

A newly issued, 4-page brochure describes a simplified procedure and calculations necessary to obtain optimum performance from 2nd and 3rd order servo systems. In a step-by-step procedure, the basic requirements for servo performance are covered, i.e., static error or accuracy and ability to follow up at a given speed or acceleration. From the information contained are derived all the parameters of the optimum servo system. Copies may be obtained from: *Application and Sales Dept. M., Ten Bosch, Inc., 80 Wheeler Ave., Pleasantville, N.Y.*

Synchro and Resolver Manual . . .

This 27-page illustrated technical discussion of the electrical characteristics of synchros and resolvers describes in detail the application and significance of such parameters as electrical error, electrical zero, fundamental null, total null, transformation ratio, and phase shift. When synchros and resolvers are used in systems, each of the "data-sheet properties" undergoes drastic change, the nature of which is thoroughly explained. Methods of measurement and the basic specifications for test equipment are also included. *Theta Instrument Corp., 520 Victor St., Saddle Brook, N.J.*

Fiberglass Moldings Brochure . . .

A color brochure illustrates specialized fiberglass moldings designed and manufactured for the electronic, avionic, and nucleonic industries. Intended by Aero-Nautical, Inc., as introductory literature, the brochure gives general information on the company's equipment, experience, and efficiency. For a free copy, write to *Aero-Nautical, Inc., 97 Garfield Ave., Copiague, L.I., N.Y.*

Epoxy-Encapsulated Miniature Motors . . .

Bulletin 1105 describes a new line of 1¼-inch-diameter hysteresis-synchronous a-c motors which develop 0.75 ounce-inch of torque at synch speed, and are epoxy-encapsulated for good environmental resistance in commercial applications. *Globe Industries, Inc., 1748 Stanley Ave., Dayton 4, Ohio.*

Electronics Catalogue . . .

A 252-page catalog contains detailed product listings on a wide variety of electronic parts and equipment, primarily for industrial and research applications. Included are an extensive selection of semiconductor products and power tubes for industry and broadcast, and a representative grouping of products for service and audio. Prepared by Electronic Publishing Company, Inc. of Chicago, the catalog is available from *Melvin Electronics, Inc., 541 Madison St., Oak Park, Ill.*

Heavy Duty Electric Impulse Counters . . .

A new 6-page bulletin, describing Sodeco Ti Series Heavy Duty Electric Impulse Counters, gives complete technical data including operating instructions, execution possibilities including several circuit diagrams, electrical information for both a-c and d-c models, and dimensional data. The bulletin illustrates and describes single register counters, impulse counters with two registers, remote add/subtract impulse counters with two drive systems, and remote impulse counters with set control contact and predetermining remote impulse counters, all of which are available with either manual or electric reset. Available from *Landis & Gyr, Inc., 45 W. 45th St., New York 36, N.Y.*

"Preparing for Patent-hood" . . .

A booklet about patents for inventors and engineers has just been revised and reprinted. Titled "Preparing for Patent-hood," the booklet tells what to do with an invention idea; when to talk with a patent attorney; importance of dates and a verifier; about the patent office; application handling; revising claims; claims and patents; economic importance of patents; and foreign patents. *Trak Electronics Co., Division of CGS Laboratories, Inc., 49 Danbury Rd., Wilton, Conn.*

Comparative Chart for Compression and Transfer Molders . . .

This new chart shows the mechanical, electrical, and thermal properties of all general purpose thermoset materials comparatively, as well as the relative position of epoxy molding compounds for flexural strength, impact strength, heat distortion, dielectric strength, etc. under conrtolled tests. Available on request from the *Fiberite Corp., Winona, Minn.*